No. 799540
476-500

THE TRUSTEES OF THE PUBLIC LIBRARY
LUX OMNIUM CIVIUM
OF THE CITY OF BOSTON
1852 · 1878

GIVEN BY
U. S. Supt. of Docs.

7995-0

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF PUBLICATIONS.

FARMERS' BULLETINS

Nos. 476–500,

7995-40
476-500

WITH CONTENTS AND INDEX.

PREPARED UNDER THE SUPERVISION OF
JOS. A. ARNOLD,
EDITOR AND CHIEF.

3594

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

U. S. SUPT. OF DOCUMENTS.

Oct. 15, 1912

Oct. 26 1912
1 1/2 cent

CONTENTS.

Page.

FARMERS' BULLETIN NO. 476.—THE DYING OF PINE IN THE SOUTHERN STATES: CAUSE, EXTENT, AND REMEDY:
Cause of the dying of pine.......... 5
Extent of losses.......... 7
The remedy.......... 9
Investigations in the Southern States.......... 10
Patches of dying pine a menace to the healthy trees.......... 11
The more important evidences of the presence and work of the beetle 12
How to locate the infested trees.......... 12
Essential details in methods of control.......... 13

FARMERS' BULLETIN NO. 477.—SORGHUM SIRUP MANUFACTURE:
Introduction.......... 5
History of sorghum.......... 6
Varieties of sorghum.......... 6
Culture of sorghum.......... 10
Harvesting.......... 12
Manufacture of sorghum sirup.......... 14
Comments by representative sirup makers.......... 31
Economic considerations.......... 33
Analyses of sorghum varieties.......... 39
Statistics.......... 40

FARMERS' BULLETIN NO. 478.—HOW TO PREVENT TYPHOID FEVER:
Introduction.......... 2
The danger from typhoid.......... 4
Sanitary measures.......... 5
Vaccination against typhoid fever.......... 6

FARMERS' BULLETIN NO. 479.—EXPERIMENT STATION WORK, LXVII:
Screening cabbage seed beds.......... 5
Does it pay to spray apple orchards.......... 8
A new type of spray nozzle.......... 10
Preparation of corn for hogs.......... 11
Experiments in beef production.......... 12
Preparation of choice hams.......... 19
Factors affecting the percentage of fat in cream.......... 22

FARMERS' BULLETIN NO. 480.—PRACTICAL METHODS OF DISINFECTING STABLES:
The necessity for disinfection.......... 5
The nature of disinfection.......... 8
Disinfectants.......... 8
Details of disinfection.......... 11

FARMERS' BULLETIN NO. 481.—CONCRETE CONSTRUCTION ON THE LIVE-STOCK FARM:
Introduction.......... 5
Requirements of a good feeding floor.......... 6
The advantages of concrete floors.......... 6
How to build concrete feeding floors.......... 7
Concrete manure pits.......... 21
Concrete dipping vats.......... 26

FARMERS' BULLETIN NO. 482.—THE PEAR AND HOW TO GROW IT:
Introduction.......... 5
Dwarf and standard trees.......... 6
Propagation.......... 7
Location of the orchard.......... 9
Fertilizers.......... 10

57789—12

FARMERS' BULLETIN NO. 482.—THE PEAR AND HOW TO GROW IT—Contd. Page.

Planting the orchard........ 11
Selection of trees........ 13
Cultivation........ 15
Cover crops........ 15
Pruning and training........ 16
Protection from rodents........ 20
Diseases and insect enemies........ 20
Thinning the fruit........ 22
Gathering the fruit........ 22
Sorting and grading the fruit........ 23
Packages........ 24
The fruit room........ 24
Disposing of the crop........ 25
Abridged descriptions of select varieties of pears........ 25
Summary........ 31

FARMERS' BULLETIN NO. 483.—THE THORNLESS PRICKLY PEARS:

Introduction........ 5
Geographic distribution of thornless prickly pears........ 6
Moisture requirements........ 8
Temperature requirements........ 8
Yields........ 9
Composition and value of the forage........ 10
Soil adaptations and requirements........ 11
Ideal conditions for growth........ 12
Propagation........ 12
Planting........ 14
Cultivation........ 16
Time of harvesting........ 16
Stability of the spineless character........ 17
Transportation of the prickly pears........ 18
How to obtain thornless prickly pears........ 19
Fruit and forage varieties of prickly pears........ 20
Botanical status of thornless prickly pears........ 20

FARMERS' BULLETIN NO. 484.—SOME COMMON MAMMALS OF WESTERN MONTANA IN RELATION TO AGRICULTURE AND SPOTTED FEVER:

Introduction........ 5
Poisoning rodents........ 7
Columbian ground squirrels........ 10
Chipmunks........ 20
Side-striped ground squirrels........ 24
Pine squirrels........ 26
Woodchucks........ 27
White-footed mice........ 29
House mice........ 30
Wood rats........ 31
Meadow mice........ 32
Pocket gophers........ 36
Rabbits........ 40
Badgers........ 44
Weasels........ 45
Big game animals........ 45
Summary........ 46

FARMERS' BULLETIN NO. 485.—SWEET CLOVER:

Introduction........ 7
Different species of sweet clover........ 8
History and present distribution of sweet clover........ 11
Adaptability of sweet clover to various soils and climates........ 12
Requirements for obtaining a stand of sweet clover........ 13
Uses of sweet clover........ 21
Sweet-clover hay........ 21
Sweet clover as a soiling crop........ 24
Sweet clover as pasture........ 24
Sweet clover as a feed........ 26
Sweet clover as a soil improver........ 30
Sweet clover in rotations........ 31

Farmers' Bulletin No. 485.—Sweet Clover—Continued.

Page.
Eradication of sweet clover... 32
Seed production of sweet clover... 32
Enemies of sweet clover... 33
Sweet-clover production in different sections of the United States... 33
Summary and conclusions... 38

Farmers' Bulletin No. 486.—Experiment Station Work, LXVIII:

The feeding of a grand champion steer... 5
The utilization of dairy by-products as food... 12

Farmers' Bulletin No. 487.—Cheese and Its Economical Use in the Diet:

Introduction... 5
Cheese making... 7
Kinds of cheese used in American homes... 8
The care of cheese in the home... 11
Cheese as a food... 11
The flavor of cheese... 12
Composition of cheese and some other foods compared... 12
Nutritive value and cost of cheese and some other food materials... 14
The digestibility of cheese... 15
The use of cheese in the diet... 16
Bill-of-fare making with cheese as the central food... 17
Homemade cheese... 19
Cheese dishes and their preparation... 21
Cheese dishes which may be used in the same way as meat... 22
Cheese soups and vegetables cooked with cheese... 32
Cheese salads, sandwiches, and similar cheese dishes... 33
Cheese pastry, cheese sweets, and similar dishes... 35
Conclusion... 38

Farmers' Bulletin No. 488.—Diseases of Cabbage and Related Crops and Their Control:

Introduction... 5
Classification of the cabbage industry... 5
How the various diseases are disseminated... 7
Farm practice and its relation to the control of diseases... 9
Important cabbage and cruciferous diseases... 12

Farmers' Bulletin No. 489.—Two Dangerous Imported Plant Diseases:

Introduction... 5
The white-pine blister rust... 5
The wart disease of the potato... 19
Present method of inspection for insects entirely inadequate when applied to fungous plant diseases... 26
Summary... 29

Farmers' Bulletin No. 490.—Bacteria in Milk:

Milk—its composition and characteristics... 5
Bacteria—their nature... 5
Relation of temperature to growth of bacteria... 8
Sources of bacteria in milk... 9
Flavors in milk... 11
Souring of milk... 12
Sweet curdling and digestion... 14
Bitter milk... 15
Ropy or stringy milk... 16
Miscellaneous fermentations... 17
Disease-producing bacteria in milk... 18
The handling and care of milk... 20

Farmers' Bulletin No. 491.—The Profitable Management of the Small Apple Orchard on the General Farm:

Introduction... 5
Orchards it will not pay to renovate... 8
How to renovate an orchard... 11
Cost of renovation... 19
Profits from renovated orchards... 20
References on the subject of orchard renovation... 21
Summary... 21

Page.

FARMERS' BULLETIN No. 492.—THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE:
Introduction.... 5
The codling moth.... 5
The plum curculio.... 11
The lesser apple worm.... 16
Cankerworms.... 17
The bud moth.... 20
The apple-tree tent caterpillar.... 21
The San Jose scale.... 22
Apple scab.... 23
Bitter rot.... 26
Apple blotch.... 29
Cedar rust.... 31
Apple leaf-spot.... 35
Sooty fungus and flyspeck.... 36
Preparation and use of sprays.... 37
Schedule of spray applications.... 43
Equipment for spraying.... 45
Applying the spray.... 46

FARMERS' BULLETIN No. 493.—THE ENGLISH SPARROW AS A PEST:
Introduction.... 5
Aiding native birds against the English sparrow.... 7
Driving sparrows from roosts.... 9
Prevention of increase.... 9
Methods of destroying.... 9
English sparrows as food.... 23
Summary.... 24

FARMERS' BULLETIN No. 494.—LAWN SOILS AND LAWNS:
Introduction.... 5
General characteristics of lawns.... 5
The soil.... 6
Essential characters.... 6
Adaptability of soils of different texture for lawns.... 6
Influence of subsoil on lawns.... 9
Characteristics of a good subsoil.... 11
Importance of soil moisture.... 11
Movements of water in soils of different texture.... 12
Influence of building débris.... 13
Good drainage necessary in lawn soils.... 14
Organic matter necessary to make a good lawn soil.... 15
Effect of organic material in lawn soils.... 15
Other factors which affect lawns.... 16
Soil building for lawns, parks, parked embankments and terraces.... 17
Preparation of the soil.... 25
Fertilizers.... 26
Grasses adapted for lawn making.... 27
Other ground covers.... 35
Seed.... 36
Establishing a lawn.... 39
Maintenance of a lawn.... 43
Relation of walks and drives to the greensward.... 46
Relation of trees and shrubs to a lawn.... 47
Botanical names of grasses referred to in this bulletin.... 48
Botanical names of plants other than grasses referred to in this bulletin.... 48

FARMERS' BULLETIN No. 495.—ALFALFA SEED PRODUCTION:
Introduction.... 5
Conditions affecting the production of alfalfa seed 6
Handling alfalfa fields for seed.... 9
Harvesting the alfalfa seed crop.... 14
Utilization of alfalfa straw after thrashing the seed crop.... 18
Seed production in different sections.... 19
Alfalfa in cultivated rows.... 21
Alfalfa seed compared with hay as money crop.... 26
Alfalfa seed yields.... 27

Page.
FARMERS' BULLETIN NO. 495.—ALFALFA SEED PRODUCTION—Continued.
Continued cropping to seed and its effect on alfalfa plants........ 28
Drawbacks to the successful production of alfalfa seed........ 28
Insect enemies of the alfalfa-seed crop........ 29
Weeds affecting the alfalfa-seed crop........ 31
Adulteration of alfalfa seed........ 33
Longevity of alfalfa seed........ 34
Commercial aspects of alfalfa-seed production........ 34
Summary........ 35
FARMERS' BULLETIN NO. 496.—RAISING BELGIAN HARES AND OTHER RABBITS:
Introduction........ 3
History and characteristics of the Belgian hare........ 4
Selection of stock........ 6
Hutches and pens........ 7
Food and feeding........ 9
Breeding........ 11
Marketing........ 13
Ailments of rabbits........ 15
Conclusion........ 16
FARMERS' BULLETIN NO. 497.—SOME COMMON GAME, AQUATIC, AND RAPACIOUS BIRDS IN RELATION TO MAN:
Introduction........ 5
Prairie chicken........ 5
California quail........ 7
Ruffed grouse........ 12
Introduced pheasants........ 13
Upland plover........ 14
Killdeer........ 16
Horned grebe........ 18
Franklin's gull........ 19
Terns........ 22
Cooper's hawk........ 26
Rough-legged hawk........ 27
Sparrow hawk........ 28
Long-eared owl........ 29
Screech owl........ 29
FARMERS' BULLETIN NO. 498.—METHODS OF EXTERMINATING THE TEXAS-FEVER TICK:
Introduction........ 5
Life history of the tick........ 10
Methods of eradication........ 14
FARMERS' BULLETIN NO. 499.—EXPERIMENT STATION WORK, LXIX:
Top-dressing pastures........ 5
Making hay........ 6
A fresh-air brooder........ 10
Roosting closet for poultry........ 14
Exhibition contests for improving dairy products........ 15
Blind staggers of horses........ 19
Adobe as a building material........ 20
White and color washes........ 23
FARMERS' BULLETIN NO. 500.—THE CONTROL OF THE BOLL WEEVIL:
Introduction........ 5
Basis for means of repression........ 5
Summary of control measures........ 11

○

Issued December 26, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN NO. 476.

THE DYING OF PINE IN THE SOUTHERN STATES: CAUSE, EXTENT, AND REMEDY.

BY

A. D. HOPKINS,
In Charge of Forest Insect Investigations,
Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., October 3, 1911.

Sir: I have the honor to transmit herewith for publication a paper dealing with the Dying of Pine in the Southern States—Cause, Extent, and Remedy. It consists of a series of revised circular letters which have been used during the present year in an active campaign by this bureau through a forest-insect field station located at Spartanburg, S. C., the purpose of which has been to study the character and extent of the dying pine and to give instructions and demonstrations to the owners within the worst affected areas on the most economical and effectual means of control.

The known destructive habits of the southern pine beetle, which is the cause of the trouble, and the threatening character of the present outbreak render its immediate control of the greatest importance to the people of the South Atlantic and Gulf States. It is perfectly capable of killing a large percentage of the young and matured trees of the pine forests of the entire South, as it did in West Virginia and Virginia in 1890 to 1893.

The paper gives the essential facts relating to the insect, its work, practical methods of control, and how to protect the pine from its depredations in the future.

It is absolutely necessary that the owners of farmers' woodlots, as well as the individual and organized owners of large areas of growing and matured pine, should be familiar with the essential requirements of locating and disposing of the infested timber in order to meet with success in any effort to control it. Therefore, I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Cause of the dying of pine 5

  The southern pine beetle 5

Extent of losses 7

The remedy 9

Investigations in the Southern States 10

  Character and range of depredations determined 11

Patches of dying pine a menace to the healthy trees 11

The more important evidences of the presence and work of the beetle 12

How to locate the infested trees 12

Essential details in methods of control 13

  Requirements for success 14

ILLUSTRATIONS.

Page.

Fig. 1. Egg galleries and larval mines of the southern pine beetle 6

2. Section of pine trunk with bark removed showing the marks of the egg galleries on the surface 7

3. Bark from pine tree showing galleries of the southern pine beetle which kills the trees, and the larger mines of the "sawyer" which does not kill trees 8

4. Map showing the distribution of the southern pine beetle 9

THE DYING OF PINE IN THE SOUTHERN STATES: CAUSE, EXTENT, AND REMEDY.

During the past few years the dying of pine in the southern Atlantic and Gulf States, from Maryland to Texas, inclusive, has attracted attention and has been the subject of special investigation and extensive correspondence.

CAUSE OF THE DYING OF PINE.

In the areas designated as the shortleaf pine and loblolly pine belts, as well as in parts of the longleaf pine belt, the death of the pine has been caused by the southern pine beetle, while in Florida and certain other sections it is apparently due to a combination of other but similar bark-boring beetles.

THE SOUTHERN PINE BEETLE.

The southern pine beetle was described in 1868 under the technical name *Dendroctonus frontalis* from specimens collected in North Carolina or South Carolina.

It is a small brownish or black beetle, somewhat smaller than a grain of rice. It flies in March to December in the more southern sections, and from May to November in its northern range. It attacks the middle to upper portions of the trunks of healthy pine and spruce trees, causing their death by excavating long, winding burrows or egg galleries (figs. 1, 3), which extend through the inner layers of the living bark and mark the surface of the wood (fig. 2). Eggs are deposited along the sides of these galleries, from which young grubs (larvæ) hatch and then feed on the inner bark until they have attained the size of the parent beetles, when they mine into the outer bark and transform to the dormant (pupal) stage, and later to the adult or beetle stage. The beetles then emerge to fly in search of other living trees in which this process of attack and development is repeated.

The winter is passed in the bark of the living and dying trees in all stages of development. The more advanced individuals begin to emerge and fly in March to May and the remainder continue to develop and emerge until about the last of July, so that by this time all of the trees that were attacked during the previous fall and early winter are completely dead and abandoned by the beetles.

There are from three to five generations annually. The first generation begins with the eggs deposited by the first beetles that fly and attack the trees in the spring and by those of the overwintered broods as they make successive attacks during the spring and early summer.

The second generation begins with the eggs deposited by the adults of the first generation and so on until cold weather stops their activities.

At all times there is a more or less complex overlapping of generations, so that there is a continuous emergence and attack during the entire period of activity; consequently a continuous dying of trees within the infested areas.

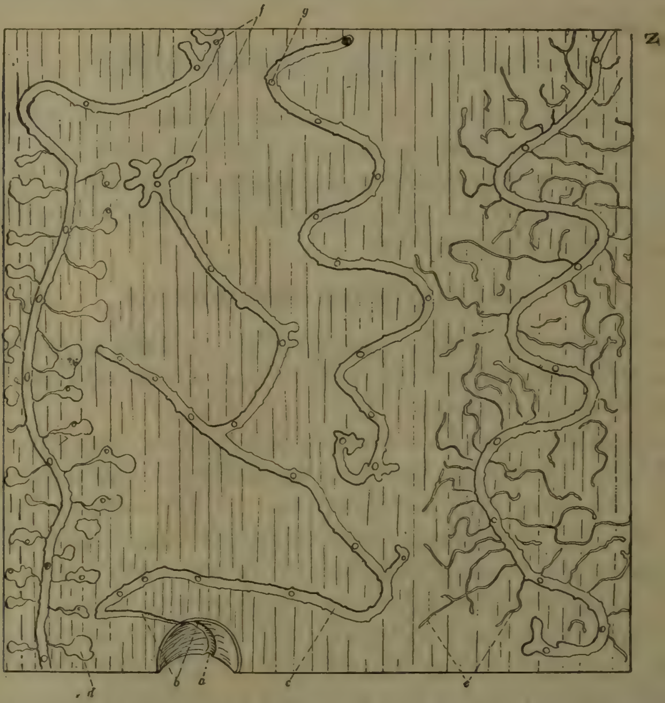


FIG. 1.—Egg galleries and larval mines of the southern pine beetle: *a*, Entrance; *b*, entrance burrow; *c*, egg gallery; *d*, normal larval mine; *e*, abnormal larval mine; *f*, terminal; *g*, ventilating burrows. Slightly reduced. (Author's illustration.)

Under average or normal conditions of the activities of this beetle a few scattering trees are killed by it each year in nearly every county throughout the Southern States where the pine is common. If, however, there are from any cause favorable conditions for the multiplication of the insect, it is thus able to kill groups of trees, and if these groups increase in number and size the following year they constitute the danger signal of an outbreak which may result in widespread depredations. Therefore it is a most destructive enemy of the pine within its range—in fact, it is, as has been frequently stated during the past 10 years, a constant menace to the living pine of all of the Southern States, from Maryland to Missouri and southward to the Gulf of Mexico. (See fig. 4.)

Evidence of the Destructive Work of the Beetle.

The presence of this beetle in dangerous or destructive numbers is plainly indicated by patches of dying and dead pine which show no evidence of injury by fire or other destructive agencies.

The trees infested by the developing broods are indicated by the fading green, greenish brown, and yellowish red of the foliage, and positively determined by the removal of some bark from the *middle* of the trunks of a few of the dying trees and the finding of the characteristic work in the inner bark and on the surface of the wood, as shown in figures 2 and 3.

The trees which have been killed and abandoned by the developed broods of the beetles are indicated by the reddish-brown foliage (abandoned red tops), the fallen foliage (abandoned black tops), and the decaying standing or fallen trees (abandoned broken tops and snags, fallen trees, etc.). The cause of the death of trees of any of these stages is determined by examining the dead bark for evidence of the work of the beetle.

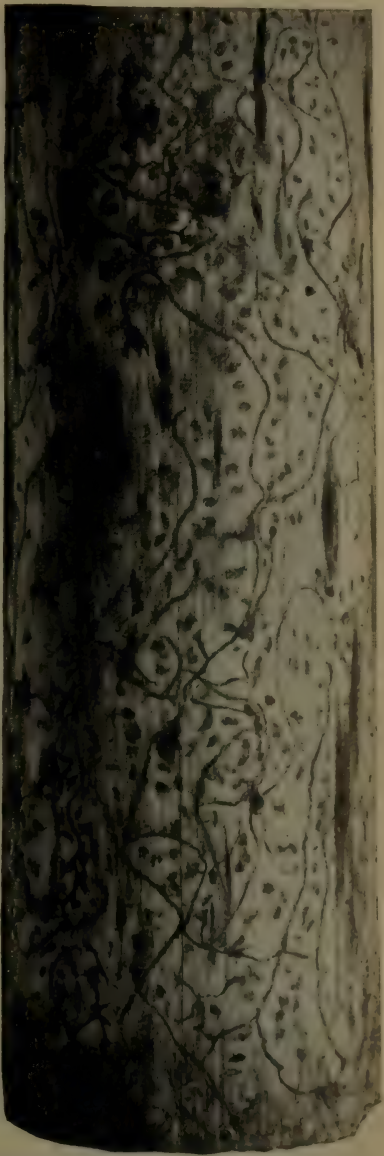


FIG. 2.—Section of pine trunk with bark removed, showing the marks of the egg galleries on the surface. (Author's illustration.)

EXTENT OF LOSSES.

Extended observations in all of the Southern States during the past 20 years lead the writer to conclude that if all of the pine that has been killed during this time by this beetle was living to-day its stumpage value would amount to from $10,000,000 to $20,000,000 or more. Recent studies of the depredations wrought by it in the South Atlantic and Gulf States during the past three years indicate that at least $2,000,000 worth of pine has been killed. It is also evident that

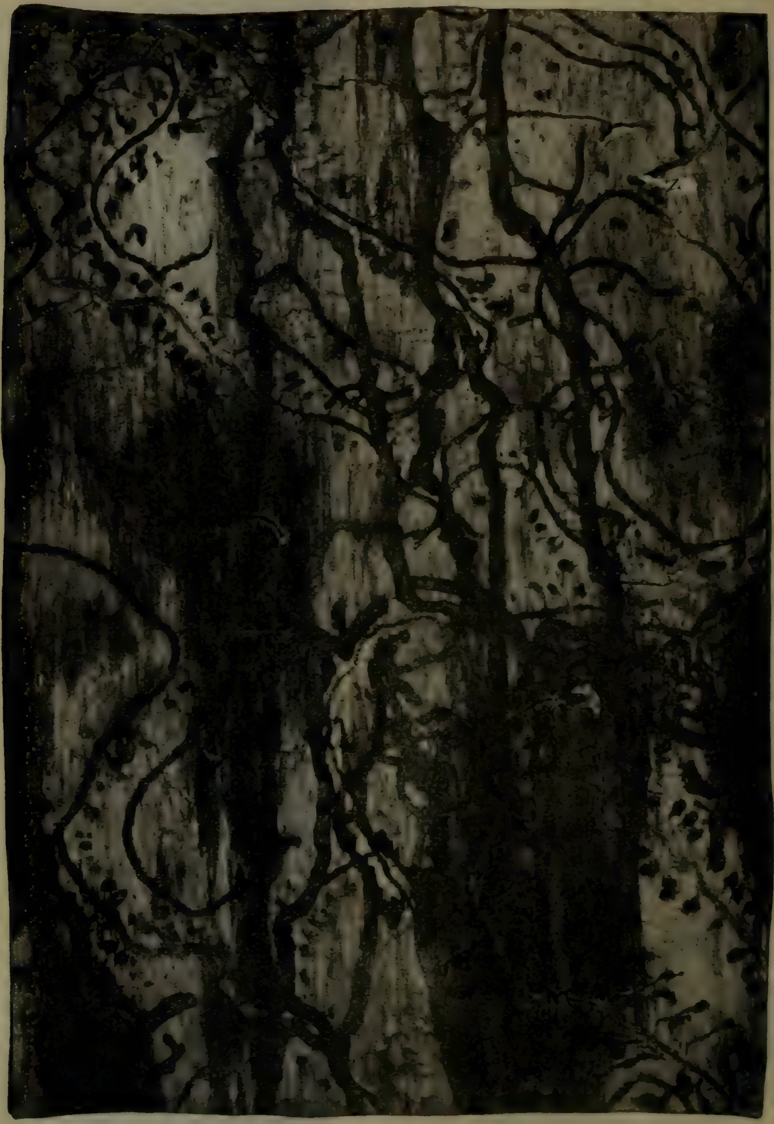


FIG. 3.—Bark from pine tree showing galleries of the southern pine beetle, which kills the trees, and the larger mines of the "sawyer," which does not kill trees. (Author's illustration.)

if active steps are not taken this winter by the principal owners in the infested areas this loss will be increased to another million dollars within the next year.

THE REMEDY.

It has been determined and demonstrated that if the larger part of the infestation within an area of 8 or 10 square miles is disposed of according to the methods discovered and recommended by the experts of the Bureau of Entomology, it will bring the beetle under complete control in that area, and that thereafter control can be maintained with but slight trouble or expense. It is, therefore, evident that if the recommended methods are adopted and properly carried out the beetle can be controlled in any given community, district, county, State, or the entire South.

THE METHOD OF CONTROL.

Broadly stated, the method of control is to locate the infested trees during November, December, January, February, and March, and destroy the overwintering broods in the bark of the main trunks, according to the recommendations on pages 13 and 14 of this bulletin.

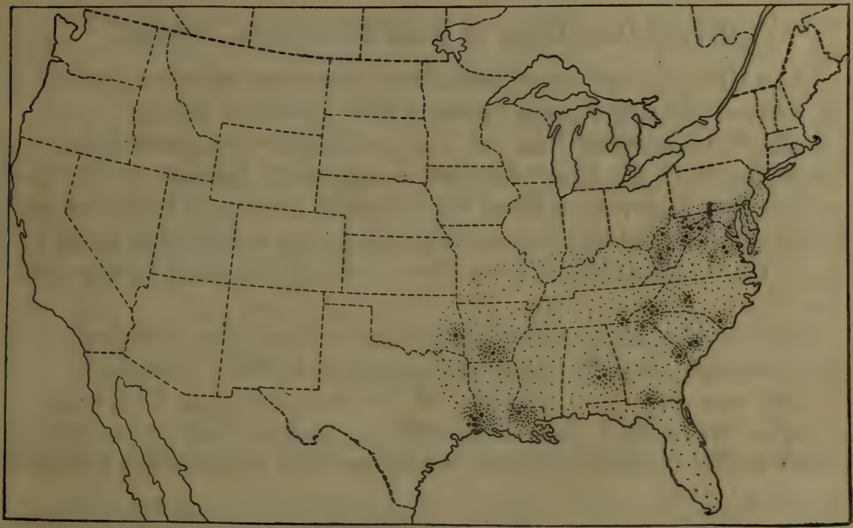


FIG. 4.—Map showing distribution of the southern pine beetle. (Author's illustration.)

THE COST OF CONTROL.

Experience has shown that while a large amount of timber may be dead in a given locality, it may be an accumulation of several years or months through the continued dying of the trees, so that only a comparatively few infested trees are found at any given time. Therefore, if this small number of dying and infested trees is disposed of at the proper time and in the proper manner, the cause will be removed at small cost and the dying of the pines will stop.

The cost for the required treatment will ordinarily average about 16 cents per tree.

Protecting the *living* pine of farmers' woodlots and small forests of average infested areas of 10 to 15 square miles in the central Southern States, through a direct control of the beetle, will cost from 1 to 10 cents per acre for the first year, and practically nothing thereafter for from 10 to 20 years.

The protection of the *living merchantable* pine within a similar average area will cost from 5 to 30 cents per thousand feet board measure, or from ½ cent to 10 cents per cord for the first year and practically nothing during the next 10 to 20 years.

If the treated timber can be utilized for fuel, lumber, or any other purpose involving a commercial value, the cost will be reduced to a minimum, and in many cases a direct profit will be derived from the sale of the treated product.

INVESTIGATIONS IN THE SOUTHERN STATES.

From time to time since 1842 there have been reports of more or less extensive dying of pine timber in the Southern States.

Extended investigations of the problem were started by the entomologist of the West Virginia Experiment Station in 1891 and continued at intervals in West Virginia until 1901, and by the experts on forest insects of the Bureau of Entomology at different times and in all of the Southern States from July, 1902, until the present time.

The results of these investigations have shown that the death of a large percentage of the pine of Virginia and West Virginia in 1890 to 1893 was due to an invasion of the southern pine beetle, which attacked the healthy trees and girdled and killed them by excavating long winding burrows beneath the living bark on the main trunks of the trees.

It has also been shown that this beetle has existed in the Southern States for at least 40 years, and there is good evidence that it has occupied this region from time immemorial, but it is only at comparatively long intervals that it increases to such numbers as to cause widespread depredations.

During the summer and fall of 1910 and the winter and spring of 1911, correspondents of the Bureau of Entomology in different sections of the South, and especially in the Atlantic and Gulf States, reported that the pine was dying in patches, and that in some places the trouble was alarming. Therefore, it was made the subject of special investigation in May, June, and July, 1911, which resulted in the location of a forest insect field station at Spartanburg, S. C., for the purpose of studying the character and extent of the depredations and conducting a campaign of instruction and demonstration on the proper methods for controlling the beetle and protecting the remaining living timber. This work has been prosecuted in such a manner as to convince the majority of the owners of pine within the areas covered by the representatives of the Bureau of Entomology that the southern pine beetle is a menace to the pine forests of the Southern States. There is now a general and widespread interest manifested throughout the worst affected sections, and there is every prospect that if general action is taken by the owners, in the utilization or treatment of infested trees according to the recommendations of the experts of the Bureau of Entomology, the beetles can be controlled this winter at slight expense, and that the remaining living pine will thus be protected from further depredations.

CHARACTER AND RANGE OF DEPREDATIONS DETERMINED.

Since the location of forest-insect field station 7 at Spartanburg, S. C., on July 5, 1911, the agents of the Bureau of Entomology, United States Department of Agriculture, detailed to the station have been very active in the study of the character and extent of the depredations by the southern pine beetle in South Carolina, Georgia, Alabama, North Carolina, Mississippi, Texas, Florida, Virginia, Louisiana, Maryland, Arkansas, Missouri, and Tennessee. Observations by the agents and information conveyed by correspondents from all sections of the South show that in the aggregate a vast amount of timber has been killed by the southern pine beetle during the past two years. The dying and dead trees occur as scattering individuals or in clumps, large patches, and in some places whole forests. All are more or less conspicuous by their fading, red, black, or denuded tops, plainly indicating the presence of the beetle or the progress of its work.

PATCHES OF DYING PINE A MENACE TO THE HEALTHY TREES.

It has been found that each patch of dying trees with their fading and greenish-brown tops located anywhere in the Southern States is a menace to the living pine within a radius of 3 or 4 miles. The broods of the southern pine beetle developing in the bark of the trees of one such center of infestation may swarm in any direction and settle in the healthy timber. Thus one or more additional patches is killed until nearly all of the large as well as the small pine over an extensive area is dead.

When these centers of infestation are numerous within the confines of a county, or even a larger section of territory, they can only be compared with the starting of so many forest fires, and, as has been demonstrated, they may lead to far greater destruction of merchantable pine than has ever been recorded as resulting from fire in the Southern States. Therefore they demand similar prompt and radical action on the part of the owners in order to protect their living pine.

THE MORE IMPORTANT EVIDENCES OF THE PRESENCE AND WORK OF THE BEETLE.

(1) If in clumps or patches of pine, where there is no plain evidence of serious injury by fire, the foliage fades to pale green and changes to yellowish and pale brown, it indicates that the trees are dying from the attack of the southern pine beetle, and that the bark on such trees is infested with the developing broods of minute white grubs and transforming beetles. Therefore such infested trees are a *menace to the living trees.*

(2) If the trees have reddish brown and partially fallen foliage, or if all of the foliage has fallen, it indicates that the broods of beetles have emerged and that such trees are no longer a menace to the living ones.

(3) If the trees die during the period between the 1st of March and the 1st of October, they will be abandoned by the broods of beetles within a few weeks after the foliage begins to fade.

(4) If the trees begin to die during the period between the 1st of October and the 1st of December the broods of beetles will remain in the bark until the following March or April.

HOW TO LOCATE THE INFESTED TREES.

The location of trees that are infested by the southern pine beetle is the first and one of the most important things to do before definite plans are made for the active work of cutting the trees. Some of the essential things to remember are as follows:

(1) The southern pine beetle attacks the upper and middle portions of the trunks of healthy trees.

(2) A freshly attacked tree may show pitch tubes on the trunk, reddish boring-dust around the base, or there may be no external evidence of attack until the leaves begin to fade.

(3) By the time the tops are faded and the bark on the middle and upper trunk is dead the broods of the beetles are in an advanced stage of development; yet, at the same time, the bark on the lower third of the trunk may be living and show no evidence of attack, or may be attacked by other kinds of insects which are not responsible for the death of trees.

(4) As soon as the bark begins to die on any part of the trunk it is attacked by numerous other insects, including the adults of the "sawyer" borers which do not attack healthy trees.

(5) By the time the tops have changed from pale green to greenish brown the broods of the southern pine beetle are nearly all developed to the stage when they enter the outer bark to transform to the adults.

(6) By the time the tops have changed to a reddish hue the broods have developed and are either emerging or have emerged.

(7) During the warm months the broods will develop and emerge from a tree within about 30 to 40 days after it is attacked.

(8) Trees attacked in November will usually carry the broods over winter. The foliage of some trees will fade and reach the reddish stage before spring; other trees attacked in December or later may not fade until the warm days of February, March, or April.

Therefore, in estimating the character and extent of an infestation within any given area, or in locating infested trees and marking them for utilization or treatment, one has only to consider those with fading or greenish brown foliage, or the first stage of the yellowish red tops.

ESSENTIAL DETAILS IN METHODS OF CONTROL.

There are certain essential details in the recommended methods of combating the southern pine beetle which must be observed in order to avoid not only serious mistakes but possibly ultimate failure:

(*a*) The principal clumps or patches of *dying* trees which are actually infested by the broods of the destructive beetle, as indicated by the *fading and dying* foliage, or otherwise, should be located and marked during the months of November, December, January, and February. In order to do this work, proper experience or special instruction is required. Therefore, some one who has had instructions should have charge of the work in each important area in which control work is to be undertaken.

(*b*) The *broods of the beetle* in the bark of the *main trunks* of the medium to larger sized dying infested trees within an area of 8 or 10 square miles or more must be destroyed in order to stop their depredations.

(*c*) The broods may be destroyed by *one* or *more* of the following methods, the work to be done between the 1st of November and the 1st of March:

(1) Removing and burning the infested bark from the trunks of the standing trees; or

(2) Removing and burning the infested bark from the trunks of the trees after they have been cut down; or

(3) Scorching the infested bark, or burning the wood with the bark after the trees are cut down; or

(4) Placing the infested portions of the trunks in water; or

(5) *Converting the trunks of the infested trees into cordwood and using the wood for fuel before the beetles leave the bark;* or

(6) *Converting the infested trees into lumber or other products and burning the slabs or bark.*

(*d*) It is not necessary to burn the tops or branches of treated trees or to cut and burn small infested saplings *if the larger infested trees are disposed of.*

(*e*) It is not necessary to remove or destroy the bark on the lower portion of the trunks or on the stumps if it is not infested with the destructive beetle, and it is not necessary to cut or treat dead trees from which the beetles have emerged.

(*f*) It is necessary and essential that the broods of the destructive beetle in the bark of any portion of the main trunks of the medium to larger sized dying infested trees of any given locality should be destroyed.

(*g*) If the wood of the infested trees can be utilized for fuel, lumber, or other purposes, its value should cover the cost of the work. If the work of felling and barking the trees is done at direct expense, the cost will average 10 to 30 cents per tree.

(*h*) The cost of protecting the living timber of any locality with average infestation should not exceed an average of from 1 to 5 cents per acre for the total area of pine-covered land, and if estimated on a basis of volume it should not cost over 2 cents per cord of the living timber protected.

(*i*) The best time to conduct control operations against the southern pine beetle is during the period between November 1 and March 1.

(*j*) If a pine tree standing among or near a groove or woods of living pine is either struck by lightning or felled and barked or split into cordwood during the summer and early fall, it will, as a rule, attract the beetles within a radius of 3 or 4 miles and result in the starting of a new center of infestation and in the death of a large number of trees.

(*k*) The principal owners of pine in each community should cooperate in the disposal of the required infestation but should not undertake the work until *some one or more of the owners is sufficiently familiar with the essential details of the proper methods.*

REQUIREMENTS FOR SUCCESS.

The requirements for success in any effort to protect the living pine from the destructive attacks of the southern pine beetle are the destruction of the broods of the beetle in the bark of the main trunk of the dying infested trees before they leave the bark. This is accomplished by the adoption of one or more different methods of direct utilization of the infested trunk, or treatment at direct expense in cases where the wood can not be utilized.

The attainment of the best success from the practical application of any of these methods will depend on their adaptation to local conditions and requirements for disposing of the infested timber and strict adherence to certain details which are absolutely necessary to the destruction of the broods.

The period in which to locate and mark the trees that are actually infested and in which the marked trees should be utilized or treated to kill the broods is between the 1st of November and the 1st of the following March, but in some cases the period may be extended to the 1st of May.

The adoption of the method of destroying the broods which in each case is the most economical and effectual can be determined by the owners in each community if they are sufficiently informed on the essential facts.

Detailed advice, recommendations, or conclusions as to the most economical and effective method of procedure for any given area should be deferred until certain reliable information is at hand in regard to the local condition as to (*a*) the character and extent of the infestation, (*b*) the interest manifested by the people of the community in the value to them of the pine and the importance of protecting it as the source of future revenue, (*c*) the assurance of the majority of the owners that concerted action will be taken according to a definite plan and purpose, and finally, if a demonstration is desired, that local facilities will be offered for its successful prosecution.

If the owners of pine will consider the protection of their timber from the standpoint of a common interest and will realize the necessity for concerted action in the control work, success will be assured.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued February 9, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 477.

[SUPERSEDING 135.]

SORGHUM SIRUP MANUFACTURE.

BY

A. HUGH BRYAN.
Chief, Sugar Laboratory.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., September 28, 1911.

Sir: I submit herewith, for your inspection and approval, the manuscript of Farmers' Bulletin No. 477, prepared by A. H. Bryan, Chief of the Sugar Laboratory. This bulletin is to take the place of Farmers' Bulletin No. 135, by A. A. Denton, which was published about ten years ago, and which in turn superseded No. 90.

The text has been drawn in part from the former bulletins and from those of C. R. Ball, of the Bureau of Plant Industry, also in part from experiences of old makers of this sirup. The material under the heading Culture of Sorghum has been supplied by Mr. A. B. Connor, of the Bureau of Plant Industry, who has had much experience in recent years with this crop in the West.

It is hoped that the bulletin, in its revised form, may prove as useful as its predecessors to those interested in the extension of this industry, the demand for this information having continued during the past ten years.

Respectfully,

F. L. Dunlap,
Acting Chief, Bureau of Chemistry.

Hon. James Wilson,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

SORGHUM-SIRUP MANUFACTURE

A. HUGH BRYAN,
Former Chief, Sugar Laboratory

Revised by C. H. HUDSON, Chemist in Charge, Carbohydrate Laboratory, and
S. F. SHERWOOD, Assistant Chemist, Carbohydrate Laboratory

SUPERSEDED BY 1389

FARMERS' BULLETIN 477

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C. Issued February 9, 1912; revised February, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

THIS BULLETIN describes the varieties of sorghum and tells how to plant, cultivate, and harvest the crop. It gives the methods for manufacturing sorghum sirup, often incorrectly termed sorghum "molasses," with illustrations of the apparatus used. The approximate yields of cane, of sirup, and of sorghum seed are given. Economic considerations as to the location and arrangement of a sorghum-sirup plant, fuel used, the by-products and their uses, and making sirup on shares are set forth. Tables showing the sugar content of juice from typical varieties of sorghum cane and statistics for the yield of sirup by States from 1859 to 1909 are included.

The bulletin should be of value to farmers in the sorghum-producing sections of the country and to manufacturers of the sirup.

SORGHUM-SIRUP MANUFACTURE.

CONTENTS.

	Page.
Use of sorghum for sirup	3
Varieties of sorghum	4
Culture of sorghum	8
Manufacture of sorghum sirup	11
Extraction of the juice	11
Settling the juice	13
Clarification of the juice	16
Manufacture of sorghum sirup (*Contd*):	Page.
Evaporation or concentration	19
Treatment of finished sirup	25
Canning sirup	27
Prevention of crystallization	27
Economic considerations	29
Analyses of sorghum varieties	34
Statistics	36

USE OF SORGHUM FOR SIRUP.

SORGHUM is more widely distributed than sugar cane or sugar beets, gives large yields per acre, and is easy to cultivate; at the same time it has a relatively high sucrose content. When the extension of the sorghum industry was first advocated, therefore, it was thought that this crop would play an important part in supplying the nation with sugar. Experiments showed, however, that the juices of this plant, while rich in sucrose, contained some reducing sugars, as well as a fairly large percentage of gums and gummy material which upon concentration retarded the crystallization of sucrose or cane sugar. It was also found that the yield of crystallizable sugar was low in comparison with that of sugar cane and sugar beets. At the close of these experiments the use of sorghum cane for the production of sugar was dropped to a great extent, but the plant continued to be used in making sirup. Although at the present time little or no sugar is derived from sorghum cane, the manufacture of sorghum sirup is an important industry in many States. The average quality of the sirup now produced is superior to that of sirup formerly made. This is doubtless due to the fact that modern evaporators enable the manufacturer to produce a lighter colored, better flavored sirup than was possible with the old-fashioned kettles and pans.

The terms "sirup" and "molasses," often used interchangeably in connection with sorghum, denote altogether different products. Sorghum sirup is the concentrated juice of the sorghum plant with or without the addition of the usual clarifiers, while sorghum molasses is the liquid residue coming from the draining or centrifuging of sorghum sugar. As very little, if any, sorghum sugar is manufactured to-day, the product of farm manufacture could hardly be termed "sorghum molasses." This confusion of terms may be due in part to the fact that molasses is generally heavy and thick, while sirup is lighter and thinner. Ordinary sorghum sirup is heavy in appearance, due to the gummy material present, resembling molasses more than it does a maple or cane sirup of equal density.

The manufacture of sorghum sirup is not a complicated process requiring special skill. It does not necessarily call for expensive apparatus or machinery nor are dangerous chemicals employed. The processes to be described are simple, but as in all sugar or sirup making cleanliness and dispatch are necessary, and unless one is very careful, numerous unsuccessful trials may be made before a fine sirup is produced.

VARIETIES OF SORGHUM.[1]

In the broad sense of the word, sorghum includes all the groups popularly known in this country as sorgo, sweet sorghum or saccharine sorghum, kafir, broom corn, shallu, kowliang, durra, and milo, but only the first group is of practical interest. Saccharine sorghums are recognized by their sweet sap or juice. They are, as a rule, tall with a leafy growth, branching only sparingly at the upper nodes or joints, and not stooling much at the base under ordinary cultivation. The seed head varies from the close compact "club" head of the Sumac sorghum through the rather more open heads of Orange and Gooseneck, to the loose and often widely spreading heads of the Amber and Honey varieties.

Beginning with the original importation of a single variety of Chinese origin in 1853, there were in 1906 probably no less than 200 so-called varieties in cultivation. Most of them, however, never attained any prominence outside of the locality where they originated. Ball has divided the sweet-sorghum varieties into three or four groups, each consisting of a single well-marked variety and a number of forms derived from it. Such groups are the Amber, Orange, Sumac, and Gooseneck sorghums.

AMBER SORGHUM.

Amber sorghum is said to have developed in Indiana from the original Chinese sorghum. It is an early variety and is sought for that reason. It soon was called Early Amber, and when the seed came from Minnesota was known as Minnesota Early Amber. From 70 to 100 days are necessary for the Amber sorghum to reach maturity, the time varying according to the latitude, season, and soil. It is characterized by the rather slender stalks and comparatively few and narrow leaves; the seed heads are generally black in color, varying in shape and size, and rather loose (fig. 1). One variety of this Early Amber, known as Folger, is a strain originated as an improved sirup variety having all the characteristics of Amber sorghum. Other varieties of some prominence are the Red Amber and the Minnesota Amber.

---

[1] The notes and description of varieties are taken in part from Farmers' Bulletin 246, "Saccharine Sorghums for Forage," by Carleton R. Ball.

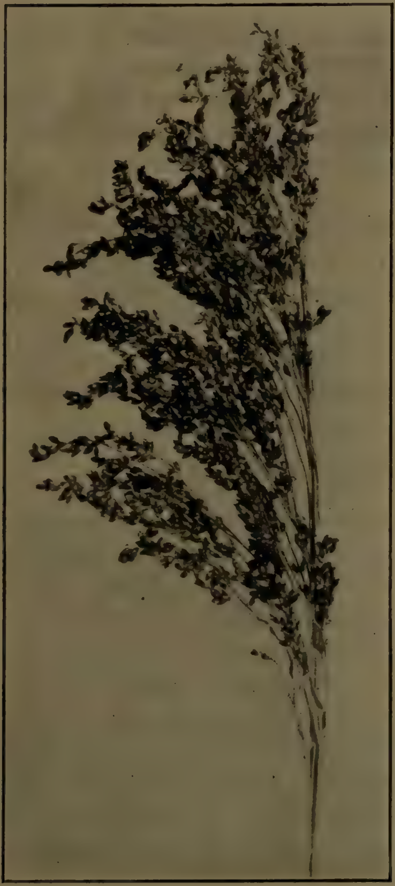


Fig. 1.—A head of Amber sorghum (about one-fourth natural size).

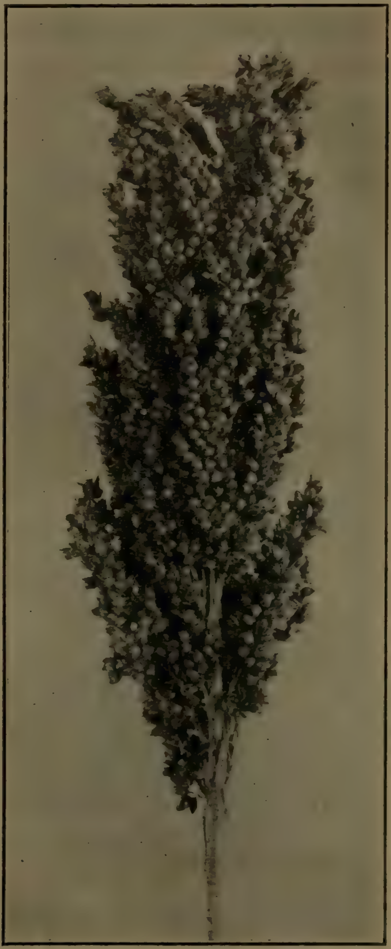


Fig. 2.—A head of Orange sorghum (one-half natural size).

ORANGE SORGHUM.

Orange sorghum which is of South African origin differs from the Amber variety in having larger and heavier stalks, larger and more abundant leaves, and heavier and more compact seed heads (fig. 2). The seeds just before ripening are almost white. The

Early Orange, as this standard variety is usually called, requires about two or three weeks longer than the Amber to reach maturity. On account of its growing taller and the stalks larger, it gives a slightly heavier yield per acre. Various forms of this variety are offered on the market, including Kansas Orange and Late Orange.

The Colman variety, which is said to have originated as a hybrid between Early Amber and Orange sorghum, is used by many for sirup making and has been shown at times to give a juice richer in sugar than any other (see Table 4 for analyses of this variety). In size, character of the seed head, and time required for maturity it is almost identical with Orange sorghum.

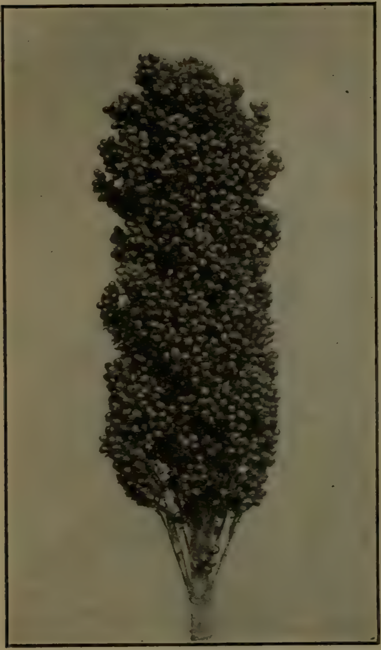


FIG. 3.—A head of Sumac sorghum (one-third natural size).

Another variety formerly grown extensively for sirup is the Collier, which when first introduced and given its name was a distinct variety, quite different from Orange. The pure Collier seems to be no longer grown (see Table 4 for analyses).

SUMAC OR RED-TOP SORGHUM.

Sumac or Red-Top sorghum may quite certainly be identified with the varieties brought from Natal. It is a stout, stocky variety with an abundance of large, broad leaves; the seed heads are stout, thick, cylindrical and erect, and the reddish-brown seeds are the smallest of any (fig. 3). This variety grows from 7 to 10 feet high, according to its environment, is usually of a very even growth throughout a field, and matures rather early, requiring from 90 to 120 days. It is cultivated quite extensively in the South.

GOOSENECK SORGHUM.

Gooseneck sorghum is distinct from any of the others grown in this country and is thought to be a direct descendant from one of the original African varieties. Its name is probably derived from the recurved and pendent stems, reddish in color (fig. 4). It grows commonly from 10 to 12 feet high and when thinly sown, for sirup making, the stalks are from 1 to 1½ to 2 inches in diameter at the butt. This variety was extensively grown in the South, especially

Texas, but being a much later ripener than Amber and a week or 10 days later than Orange and Sumac, it can not be grown in the Northern States.

HONEY SORGHUM.

Another variety of some prominence is the Honey. Its origin can not be definitely traced, but no doubt it came from an African importation. The stalks are from 7 to 10 feet high, averaging 13 to 18 nodes in different localities, are stout, from 1 to 1½ inches in diameter at the base, and very sweet. The stems are markedly tender in comparison with other stout varieties. It is, however, a very late ripener, requiring from 130 to 140 days to mature, and therefore is best adapted to the South.

SELECTION OF A VARIETY.

From the preceding discussion it is seen that for northern regions, where the growing season is short, some form of Early Amber or of Early Orange, preferably the former, must be selected, while farther south all the varieties may be used. A variety grown one season may produce a good sirup, but under different climatic conditions another year may not yield so good a product. The nature of the season seems to exert a marked influence on the composition of the plant, as has been definitely determined in the case of other sugar-bearing crops.

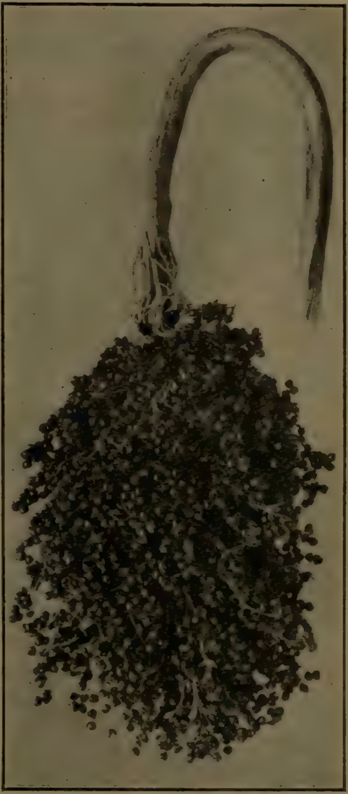


Fig. 4.—A head of Gooseneck sorghum (one-third natural size).

When a variety has repeatedly given good yields and a good quality of sirup, the seed should be carefully selected for replanting. To do this, place several typical canes [1] in shock, cover them with a net or other protection from birds, and when quite dry cut the seed heads and place them in a stout grain bag. The seed can be threshed by pounding with a club and cleaned by pouring from one pan to another in a gentle breeze. Stems and trash can be removed from the seed by shaking the pan and picking them out as they come to the surface. In this way an unmixed seed of good quality can be obtained by the sirup maker.

---

[1] Comparison of the size of seed head and sugar content of stalk has led to the generalization that individual cane with larger seed heads than their fellows have a lower content of sugar. (A. A. Denton) U. S. Dept. Agr., Bureau of Chemistry Bul. 26, p. 94.

CULTURE OF SORGHUM.[1]

While sorghum is a crop generally thought to require little attention, its yield and value can be materially increased by using care in its culture. Good seed of the right variety is necessary for the best yields, but there are other equally important factors that must not be neglected, such as preparation of the soil, time and rate of seeding, and manner of planting. Perhaps more failures to secure satisfactory crops are due to improper seeding than to any other cause, and too great care can not be given to planning for and planting the crop.

PREPARING THE SEED BED.

Although a large portion of the land planted to sorghum is left unplowed until a short time before seeding, this practice is by no means advisable. For the best yields there must be a firm seed bed, obtained by plowing the land early in the fall and harrowing or disking to keep down weeds until seeding time. Such preparation allows whatever vegetation there may be in the soil to decay and leaves it in the best tillable condition. In the drier regions this treatment serves to take in and retain any moisture that may come during the winter season and to decrease the chance of failure from drought. In the same manner it increases the yield in more favorable seasons. In the more humid sections early preparation is preferable, though not so necessary as in the drier regions. The land is sometimes prepared by "bedding" or listing with a middle buster or a turning plow.

PLANTING.

The planting of sorghum deserves more careful attention than any other operation entering into the production of the crop. The time, method, and rate of seeding mean success or failure in the degree in which it has been properly or improperly done. It is therefore of vital importance that the farmer attend carefully to the planting of his crop.

Time of planting.—The sorghums are usually planted soon after corn, when the ground is thoroughly warm. They may be planted at any time after that date until as late as will permit the crop to mature safely. In the Southern States the first of April is considered early planting. Northward, using the northern line of Louisiana as a base, the season grows later at the rate of about one week for every 2 degrees, or 150 miles. Early seeding is preferable for the reason that it may produce a second crop which can be used for forage. It is usually well to make two or three different plantings at intervals of about ten days or two weeks so that all the crop will not mature at the same time.

---

[1] This section was prepared by A. B. Connor, Bureau of Plant Industry.

Method of planting.—For sirup production sorghum should always be planted in rows 3 or 3½ feet apart. This may be done with a single or double row planter either on a bed, on the surface, or in a lister furrow, depending on the section where the crop is grown. Furrow planting is most common in the drier regions, but it is practiced to some extent in the humid sections. In some of the lower and poorly drained lands planting is made on a bed, but only under such conditions should this method be used.

Rate of seeding.—The rate and regularity of seeding largely influence the yield of sirup regardless of the method used. Seeding should be done so that the plants will be very evenly distributed and average a distance of 4 to 6 inches in the row, or even more in the drier regions. It is possible to make a special plate for the drill that will plant the crop very satisfactorily and thus avoid a great deal of labor in thinning. The quantity of seed required to plant an acre is small, varying from 2 to 8 pounds, depending upon rate and method of planting.

CULTIVATION.

While sorghum will grow and give fair yields with little or no cultivation, this is by no means the most profitable method of producing the crop. Careful cultivation has repeatedly been known to increase materially the yield per acre. The first cultivation can be given with a spike-toothed harrow, and as soon as possible afterward it should be cultivated deeply with sweeps or shovels. Later in the season at least two additional shallower cultivatings should be given for the best results. Sorghum can be cultivated to advantage until it begins to put out heads, provided care is taken not to destroy the surface feeding roots.

HARVESTING.

The stage at which the sorghum contains its greatest sugar content, a matter of the greatest importance to the sirup maker, has been the subject of much investigation in former years. Collier gave the following figures as a result of about 2,740 analyses of sorghum canes made at different stages of growth:

TABLE 1.—*Sugar content of sorghum at different stages of growth.*[1]

Stage of cutting.	Sucrose.	Invert sugar.
	Per cent.	*Per cent.*
Panicles just appearing	3.51	4.50
Panicles entirely out	5.13	4.15
Flowers all out	7.38	3.86
Seed:		
In milk stage	8.95	3.19
Doughy, becoming dry	10.66	2.35
Dry, easily split	11.40	2.03
Hard	13.72	1.56

---

[1] Peter Collier, Sorghum: Its Culture and Manufacture (1884), 198.

From these figures it appears that from the time the seed is in the late milk stage until it is becoming dry the cane is in the best condition for sirup making. Some prefer to wait until the seed is hard before cutting, as the sugar content is still higher then, but they run the danger of a frost before all of the cane is worked up.

Cutting can be done by hand or by a harvester. When harvested by hand, the individual canes are cut about 6 or 8 inches above ground and laid across the rows with all the heads in the same direction. With a harvester and binder the cutting and binding in bundles forms one operation, and all the seed heads are at one end of the bundle. It is customary among some makers to leave the hand-cut cane in the field for a day or two to wilt the leaves, which is said to improve the quality of the sirup. The seed heads are removed and left in the field to be collected after the harvest. For a good grade of sorghum sirup all leaves and seed heads must be removed from the cane, as these on passing through the mill tend to impart a bad flavor to the juice and resulting sirup, introduce more or less dirt and fine particles of plant material into the juice, and retard clarification. Moreover, leaves which have become dry have a tendency to absorb juice as it is pressed out in the mill, thus decreasing the yield of juice and sirup. In removing the seed heads, about 6 to 18 inches of the upper cane should be cut off, as this part contains little sucrose and many impurities; suckers should also be discarded for the same reason.

The harvesting should progress in proportion to the mill work, no more being cut at one time than can be worked in two days. When the weather is cold the cane may be cut and shocked. Some makers have kept it in shock for four weeks with no appreciable loss in sirup-making properties. Like other sugar-producing plants, however, a freeze does not hurt the crop, provided the cane can be worked up just as soon as it thaws. On freezing the cells of the cane are broken, and on thawing, decomposition quickly sets in. A frost will not hurt a ripe cane materially, but if the cane is immature it will be spoiled. Frosted cane, like frozen cane, should be worked up as soon as possible. In Louisiana the sugar cane is "windrowed" when a frost or freeze is expected—that is, the cane is cut and laid on the ground between the rows, the leaves serving as a protection. In the case of sorghum, under such conditions, if the weather is warm during the middle of the day, the leaves on the stalk soon produce a "heating" of the pile and decomposition sets in. "Heated cane" and frosted cane do affect the flavor of the sirup. One of the large makers states that by shocking the cane with leaves and heads on he has kept it in good condition for many weeks. This, of course, was during cool weather, for even when standing in shocks the cane is liable to "heat."

As stated before, for sirup making the best stage for cutting is just before hardening of the seed. Earlier than this the cane is too green and the resulting sirup will have an unripe taste. If cut when the seeds are very hard, the juice is said to be difficult to clarify, and the flavor of the sirup is not good.

On the subject of yield but few definite data can be given, as so many factors influence it. Sorghum may yield as high as 15 tons to the acre or as low as 4 or 5 tons; an average crop is about 8 or 10 tons. The gallons of sirup per ton of sorghum depend on the kind of mill and on the care in manufacture, also the ripeness and kind of cane. A ton of cane with a 3-roller mill should yield anywhere from 700 to 1,200 pounds of juice, giving 8 to 30 gallons of finished sirup, depending upon the richness of the juice. Taking 10 tons per acre as the average yield, from 60 to 300 gallons of sirup per acre should be obtained. Information from farm producers of sirup, however, indicates that the usual yield is from 110 to 200, with an average of 155, gallons per acre. A greater yield is usually secured at large plants where the juice is extracted by passing the cane through a series of 3-roller mills and where the evaporators make for efficiency. At these mills a larger proportion of juice is extracted and less loss during evaporation and skimming occurs than is the case in smaller plants. At one large mill the yield of sirup varied from 180 to 220, with an average of 200, gallons per acre. Large amounts of juice are lost in the mills and again in skimming.

MANUFACTURE OF SORGHUM SIRUP.

This discussion is designed for the benefit of the small makers of sirup rather than for those having large, well-equipped plants.

EXTRACTION OF THE JUICE.

The ordinary method of obtaining juice from sorghum cane is by pressure—that is, running the cane between iron rollers set at a certain distance apart. Another method is by diffusion, a process in which the cane is first finely shredded and placed under pressure with water in large tanks, the water removing the sugar and soluble material. This method requires very expensive machinery and much experience, and is not used now by any sorghum-sirup makers, although it is the ordinary process for extracting the sugar from beets.

The primitive mills were made by placing two logs upright side by side in a heavy frame. To one of the logs, extending above the frame, was attached a large sweep. On turning this and feeding the cane between the rollers, the juice was squeezed out. It does not extract more than 25 or 30 per cent of the juice, and hence has little commercial value. It is doubtful whether this kind of mill is used at the present time. The wooden rollers of this form have been replaced by iron rolls, and to-day many makes of 2-roller mills are found on the market. The extraction with these is better than with the wooden rollers, but does not equal that of the 3-roller mill. The latter can be obtained with the rolls upright or horizontal. The smaller mills are operated by horses or mules, the larger ones by steam or water power. Figure 5 gives a view of a 3-roller upright mill with a shaft for a sweep operated by horsepower. Figure 6 shows a 3-roller horizontal mill for horsepower. These mills can be provided with smooth or serrated rolls. In the upright position the serrated rolls prevent the cane from twisting to one side. A good mill should be easily taken apart and new pieces substituted when breaks occur; it must run smoothly and true for good results. The rolls must be capable of adjustment to any distance from each other. In setting up such mills, care should be exercised to have the mill level and rigid on the frame or upright supports, which should be carefully braced. Without these precautions, imperfect pressing will result and a break in the mill may be caused. Figure 7 shows a power mill. These are made either single or double geared, so that they can be connected direct with some form of farm engine. Figure 20 (p. 28) shows a power mill driven by a traction engine. Power mills are to be preferred to the horse mills, as the crop can be worked up more easily and quickly. Figure 8 shows a power mill fitted with a feed table and a bagasse carrier. The former is an important adjunct to a milling outfit, especially for a power mill, as it allows the cane to be arranged in some order before entering the rolls, thereby assuring a more even feed. A bagasse carrier geared to the rolls delivers the bagasse some distance from the mill.

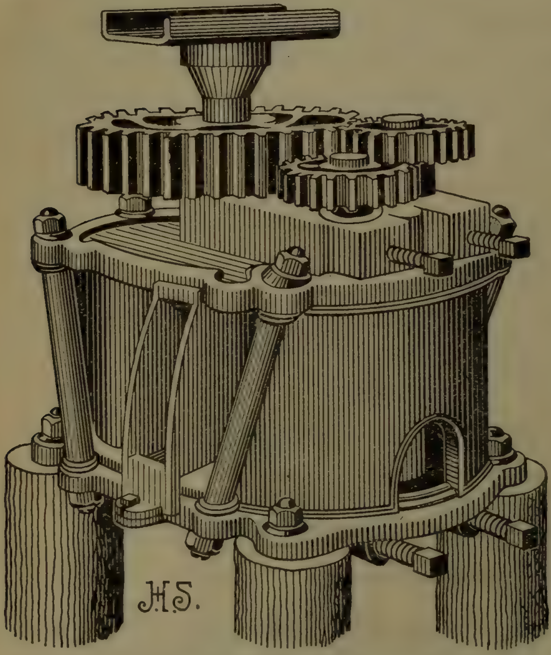


FIG. 5.—Heavy three-roller vertical horsepower cane mill.

In making sorghum on a large scale, two or more 3-roller mills may be used, one following the other. In this case, the crushed cane (bagasse) as it comes from the first 3-roller mill is often moistened slightly with water and then passed immediately into the second mill. This method increases the extraction.

Having selected a mill and set the rolls the next point to consider is how to feed the mill to obtain the best results from the cane. Sorghum ordinarily contains from 70 to 80 per cent of water and about 10 to 12 per cent of fiber, but it is not possible to obtain all of the water as juice. With a 3-roller mill, at least 50 per cent of the weight of the cane should be obtained as juice unless the cane is very hard and dry, and with a good mill and close setting 60 per cent is not too much to expect. The "feed," or amount of cane in the mill at one time, should be light or heavy according to the adjustment of rolls. When the rolls are set "open" or apart the feed should be heavy; when they are set close together the feed should be light; but in all cases it should be regular and uniform. It is evident that when the rolls are set "open" juice is wasted when the feed is light; with a close-set roll there is also a loss of juice when the feed is irregular and not even over the roll.

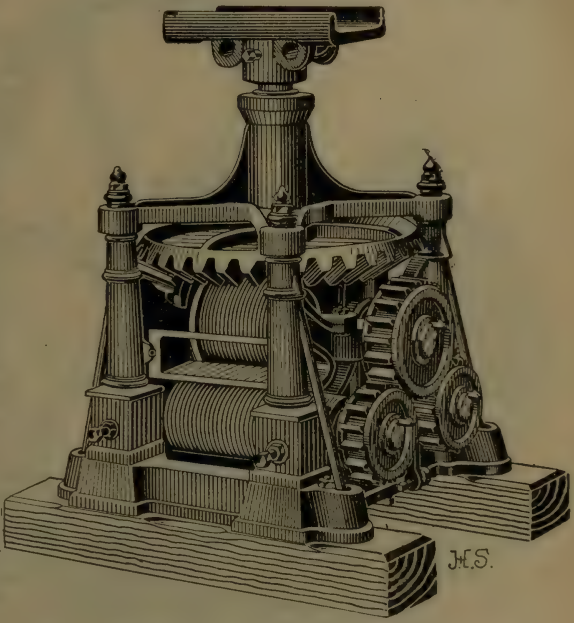


FIG. 6.—Three-roller horizontal horsepower cane mill.

Juice obtained by moderate pressing is purer than that obtained by extreme pressure, by which more impurities from the rind and joints of the cane are extracted. Sirup made from moderate pressing usually has a better flavor than that from the heavy pressing. Where cane is cheap and abundant it is inadvisable to increase the extraction of the juice greatly by excessive pressure.

SETTLING THE JUICE.

The raw juice coming from the mills should pass into collection or storage tanks. These may be merely rough barrels or metal or concrete tanks. Before entering these the raw juice should pass through a fine sieve or mesh screen to remove particles of cane, dirt, etc. There should be at least two tanks, one being filled while the other is emptied. A third tank is almost a necessity, as it allows time for the juice to settle. Raw sorghum juice holds mechanically in solution a number of impurities which on standing slowly settle to the bottom. If not allowed to settle they will collect in the evaporator at the point of entrance of the raw juice and may burn on the bottom of the evaporator. It is necessary, therefore, to remove as much as possible of this material before evaporation is begun. Heating the raw sorghum juice tends to quicken the settling of the juices. Some makers use a small boiler or feed cooker (fig. 9) for this purpose; especially is this done when the evaporation is carried on by direct fire. In the case of steam evaporation the exhaust may be used to heat the raw juice. Other makers settle this material by means of clay added to the cold or hot raw juice. A. A. Denton[1] proposed that a heavy, finely divided clay be stirred in with the juice. This tends to surround the floating sediment and carry it to the bottom, but it requires the use

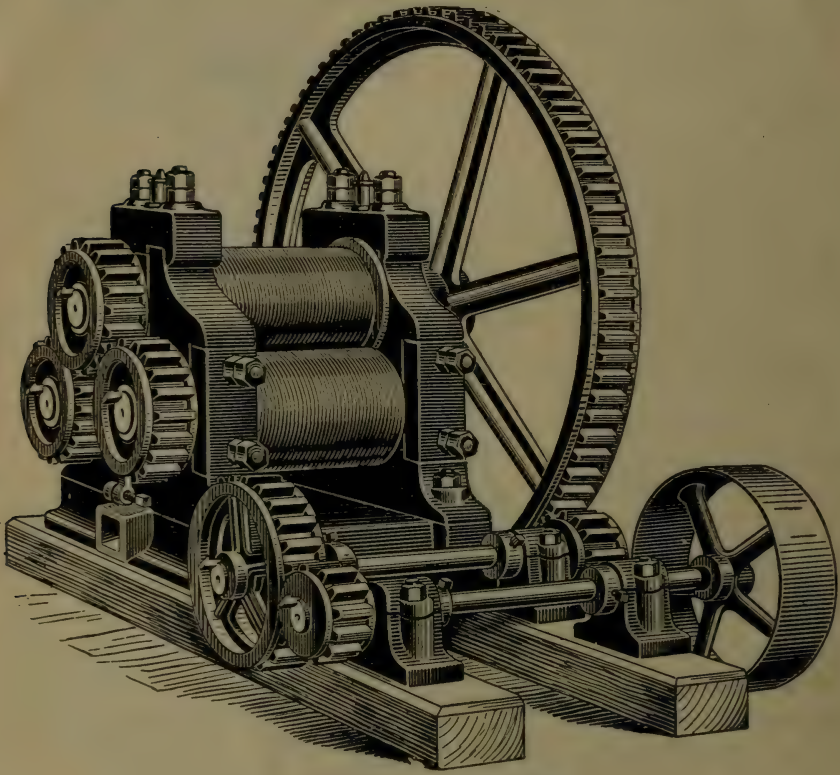


FIG. 7.—Three-roller power mill.

---

[1] U. S. Dept. Agr., Farmers' Bulletin 90.

of a heavy, coarse-grained clay, which is often not easily obtainable. An examination of some 200 samples of clay[1] collected from all over the country, showed in general: (1) That fire clays are too coarse grained and do not carry down the impurities; (2) that pure white clays are too fine grained and give bulky and indistinct settlings; (3) that blue clays, gumbo, or waxy clays are not suitable; and (4) that yellow or brown plastic clays are best. Still other makers pass the raw juice through filtering bags to remove the sediment, but this is rather tedious and does not always accomplish the purpose.

Settling tanks should be equipped with some arrangement for drawing off the clear juice without disturbing the settlings; or for drawing off first the settlings and then the clear juice. Figures 10 and 11 show such devices. Figure 10 shows a swinging barrel which can be used by manufacturers working on a very small scale. Connections suitable for tanks are shown in figure 11. Cut "A" shows an opening near the bottom fitted with a cock. By carefully opening this the turbid liquid is allowed to flow out into a small vessel and is turned into its proper tank when it begins to run clear. Cut "B" is a sliding overflow pipe, which passes through the bottom of the settling tank; by pushing the pipe down, so that its upper end is below the surface of the liquid, the clear juice is drawn from the surface down to the settlings. Cut "C" is an outside swing pipe, which draws the settlings from the bottom of the first tank, then the clear juice follows. When the long arm is turned down the liquid flows out; when it is turned up, the flow ceases.

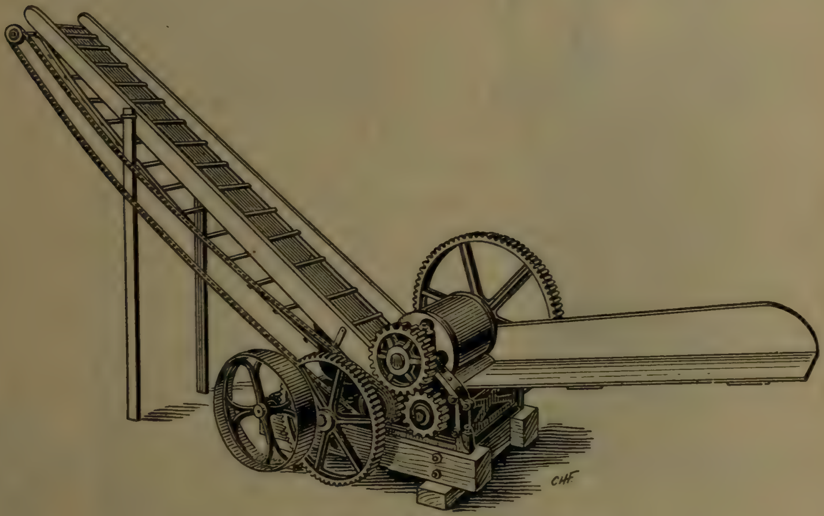


FIG. 8.—Mill with feed table and bagasse carrier.

---

[1] U. S. Dept. Agr., Bureau of Chemistry Bul. 37, p. 85.

Cut "D" represents possibly the best form for tanks. The swing pipe is placed inside the tank, and by keeping the upper end of the long arm just below the surface of the liquid the sediment is left behind. A float may be connected with the long arm, keeping it just below the surface of the liquid and arranged so as not to draw the settlings. The arm when standing erect must be long enough to reach above the surface of the liquid in the settling tank, and the swing pipe should be placed close to the bottom of the tank, far enough from the side to allow the long arm, when turned down entirely, to lie flat upon the bottom, in order to draw all the liquid as well as the sediment from the tank; the long arm of the nipple should fit the threads tightly enough to hold the weight of the pipe in any position and not allow it to drop down under any conditions. The settlings or sludge can be used for feeding hogs; but when the settling has been done hastily the sludge should be drawn off to another tank and allowed to settle more slowly, thereby saving more of the juice.

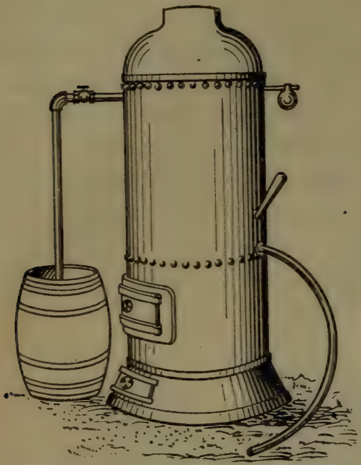


FIG. 9.—Feed cooker for heating juices.

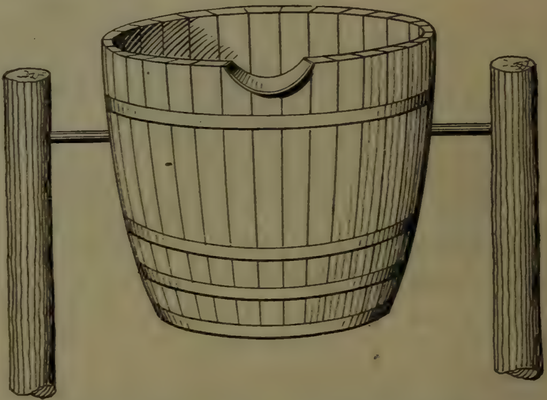


FIG. 10.—A swinging barrel for easily pouring off settled juice.

CLARIFICATION OF THE JUICE.

Clarification is designed to remove the objectionable substances from the raw juice so that a better grade of sirup may be obtained. The impurities in sorghum juice vary, depending on the season, variety of cane, pressure used in extraction, and the ripeness or condition of the cane. The undissolved impurities are removed to a great extent by settling, but those going into solution must be removed by heat or some chemical treatment. The addition of chemicals, however, while tending to throw certain impurities out, generally leaves in their place part of the foreign substance added and very often completely changes the flavor of the resulting sirup. Many schemes and many substances have been proposed for clarification. Some do the work, while the use of others is questionable.

It is suggested that as a general thing the small producer of sirup should not attempt to employ chemical methods of clarification. Great care must be used in adding chemicals for this purpose, as a slight excess of certain substances may ruin the color and flavor of the sirup. Allowing the juice to come in contact with iron surfaces should be avoided as far as possible, for iron tends to darken the color of the sirup.

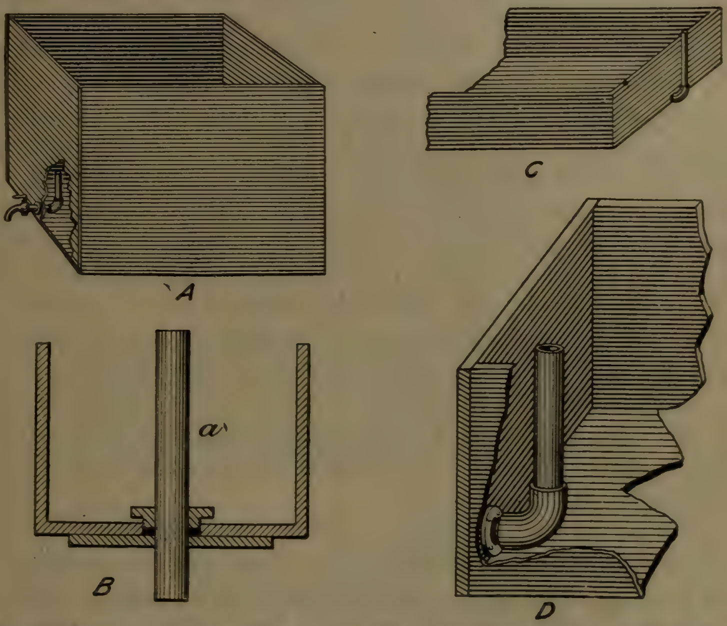


Fig. 11.—Tank connections for drawing off juice. *A*—A settling tank from which the clear liquid is drawn by an upright nipple near the bottom. *B*—A sliding overflow pipe for decanting liquids. *C*—An outside swing pipe for drawing liquid from the bottom. *D*—An inside swing pipe for decanting liquids from near the surface.

HEAT ALONE.

When the raw juice is heated a coagulation of the albuminous matter which rises to the surface and can be skimmed or brushed off occurs. In coagulating, this material tends to remove some, and generally most, of the suspended matter. Some makers provide special pans or tanks for this heating or clarification; the temperature of the juice is brought nearly to the boiling point and the heat then is turned off and the juice allowed to stand; the clear layer is then drawn off for evaporation. This process, which is to be preferred especially in the manufacture on a small scale, is also commonly used in cane-sirup manufacture.

HEAT AND LIME.

At certain seasons, and with certain varieties of cane, the raw juice may be high in acid. To partially neutralize this acidity, lime is added by some makers. This also tends to precipitate some of the organic matter. It is a question, however, whether by its use any more of the organic impurities are removed from the raw juice than by heat alone. The procedure when lime is used is as follows:

Slack completely a quantity of lime with water and then add more water to produce a thin whitewash. Strain the whole through a mesh screen, $\frac{1}{8}$ inch or even finer, to remove lumps, unburnt stone, etc. If still too thick, dilute with water. Add only enough of this solution to almost neutralize the acidity, this point to be determined by testing the juice before and after adding the lime (the whole being stirred thoroughly) by the following method: Dip a piece of blue and a piece of red litmus paper in the solution; if it is acid, the blue litmus paper will turn red and the piece of red litmus paper will remain unchanged; if the solution is alkaline, the opposite occurs, namely, the blue litmus paper remains unchanged in color while the red litmus paper turns blue. If neither one is affected, the solution is said to be neutral in reaction.

It is far better to lime lightly at first, noticing the color of the juice after the addition of lime, the tint of the blue litmus paper after wetting it in the thoroughly stirred limed juice, and the quality of the sirup produced; then add more or less lime to the next lot of juice, keeping always on the safe side—that is, the acid side. Liming should cease when the juice gives only a faint red to litmus. If it does not change the color at all, too much lime has been used, and fresh unlimed juice should be added.

Litmus paper can be obtained in "books" or in sheets. The former is a little more expensive but is easier to use. If sheet litmus is used, a piece should be cut for immediate use, clipped into small oblong pieces, and put into a small bottle, which may be corked and carried in the pocket. The rest of the sheet should be put away in a corked bottle for future use. Acid vapors in the air and fingers moist with acid juices redden and spoil blue litmus. By moistening the tip of the finger and touching one of the pieces of the blue paper it may be picked up without handling the others. In using lime for clarification the greatest care must be taken not to render the juice alkaline by the addition of an excess, which would spoil the flavor and color of the sirup.

OTHER METHODS OF CLARIFICATION.

Use of phosphoric acid compounds.—In this treatment two methods of procedure have been used. In one the phosphoric acid is added to the raw juice and then limed before heating. In the other lime is added to alkalinity, then phosphoric acid is added to a slight acidity, and the juice is heated. This procedure greatly changes the flavor of the resulting sirup, and its use is very questionable.

Use of lime carbonate or whiting.—Ordinary slacked lime is strongly caustic, while carbonate of lime or whiting is not, so less care is necessary when using whiting to avoid an excess. In using this material heat the juice and sprinkle the carbonate over the surface, reheat and sprinkle again, noting the reaction to litmus of the resulting solution. Much more whiting than lime is necessary to neutralize the acidity. Whiting can be added to settling juice to cause a better and quicker separation of the precipitated and suspended material. As in the case when lime is used, the greatest care must be taken not to render the juice alkaline.

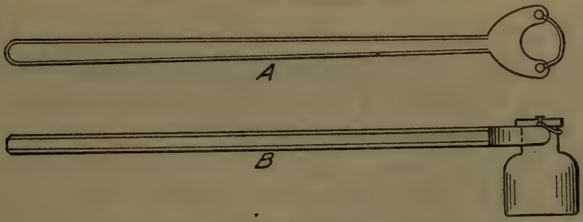


FIG. 12.—Test glass with cut of handle.

TEST GLASS AND ITS USE.

As a means of watching the progress of clarification, a test glass may be used to withdraw samples and examine them by transmitted light. Prepare a handle from a ½ to ¾ inch board about 2 feet in length and notch it as shown in figure 12. Obtain a 2 or 4 ounce wide-mouth glass bottle from a drug store and place it in the notch, then by means of a strip of sheet iron bind the bottle in place. This will be found very convenient at various stages of sorghum-sirup manufacture.

EVAPORATION OR CONCENTRATION.

The object of the process of evaporation is to remove the water from the raw juice and thereby thicken it to a sirup. This thickening may be carried to a half concentration, filtered, and the concentration completed. This procedure is quite often followed in manufacturing on a large scale, in making a sirup from overripe or underripe cane, or when much lime has been used in clarification.

USE OF KETTLES.

The simplest form of boiling apparatus is the old iron kettle. One of these may be swung from a chain or pole, or several may be arranged in a row as a battery, generally called a "Jamaica train," as shown in figure 13. The fresh juice is placed in the kettle next to the chimney and as it heats it is ladeled into the next one. The finished sirup is taken from the kettle immediately back of or over the fire box. When a single kettle is used a fire is built around the outside of it, the raw juice is poured in, and the kettle is swung in to the fire. Concentration in this form of apparatus seldom yields light-colored, good-flavored sirup. The greatest care must be used not to allow the flame to get above the level of the juice in the kettle, otherwise it will burn and have a scorched taste. Another precaution necessary when making sirup in this kind of an apparatus is to concentrate a single charge and not to add fresh juice to the boiling sirup. The latter procedure always gives a dark-colored sirup with a strong burnt flavor. After a charge has been concentrated, the kettle should be swung from the fire and the sediment washed out before it has had time to burn. If the kettle can not be removed from the fire, after two or three charges, remove the fire and clean the kettle.

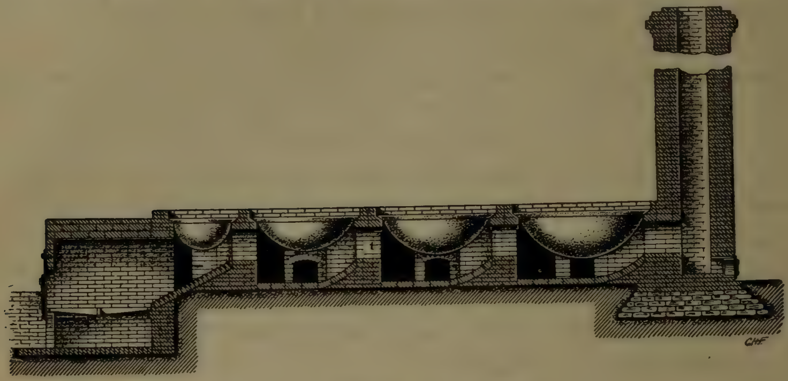


FIG. 13.—Jamaica train of kettles.

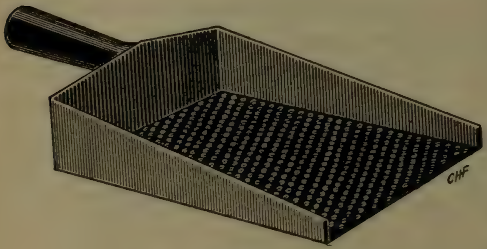


FIG. 14.—A sirup skimmer.

Any scum collecting on the surface of the boiling liquid should be removed as it forms. This is easily done with a skimmer. A sirup skimmer is made of metal, and resembles an ordinary dustpan, with the bottom perforated. It may have a short handle, as shown in figure 14, or a long wooden pole may be attached to it. Another form of skimmer often used is a pole with a narrow piece of metal fastened to it toward the end. By means of this the scum can be raked to the near edge of the pan and then be lifted off by the regular skimmer.

PANS AND PATENT EVAPORATORS.

Instead of kettles many makers use shallow pans (not over 4 to 6 inches deep) made of sheet iron, galvanized iron, or heavy tin. In this case a single pan covers the whole space occupied by the kettles or two or three pans may be used, one back of the other. These may or may not be connected so that the juice can flow from one to another. Figure 15 shows a single pan with strips to guide the juice over a zig-zag course during boiling. The raw clarified juice comes in at the fire end and the finished sirup runs out at the chimney end. In most cases these pans are lifted from the fire for cleaning at the end of the day.

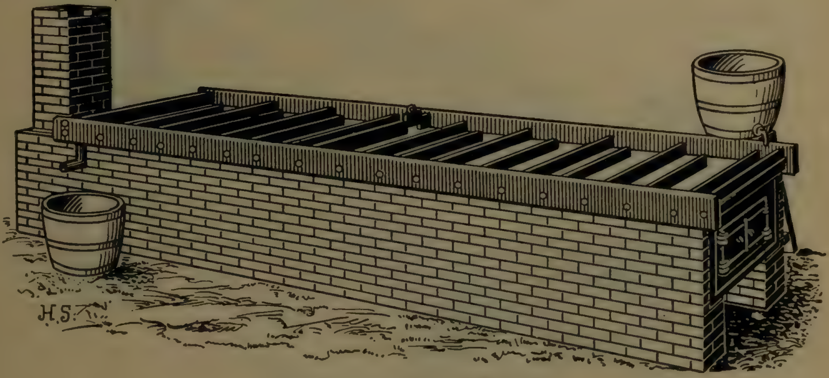


Fig. 15.—A pan evaporator.

Many improvements have been made in late years in the evaporation apparatus. Patent evaporators have many points of superiority to recommend them. The bottoms are usually corrugated to give a larger heating surface, the various compartments are connected, and an automatic supply valve is placed so that the depth of the liquid in the evaporator can be regulated. Their construction is such as to produce a quick concentration without the danger of burning or scorching the sirup.

Some makers prefer a homemade pan constructed of 1½-inch boards with a sheet-iron bottom carefully luted to the sides. This form of pan can not be recommended under usual conditions for making a good grade of sirup. After once using the wood becomes soaked with the juice, and if allowed to stand empty this juice sours and taints the next boiling. In the long run they are more expensive than iron pans, as the wood soon warps, the joints become loose, and sirup is lost.

Figure 16 shows a portable evaporator which can be easily transported from one place to another and also tilted to allow a flow of juice and sirup. It is used quite extensively in some sections of the country.

When using these forms of evaporators only a thin layer of sirup should be boiled to obtain the best grades of sirup. Not more than a 1½- to 2-inch layer of juice should be in the pans or evaporator at any time, and with care even a thinner layer might be successfully carried. A thin layer makes a quick evaporation and, as a consequence, less color is developed when concentrating to a sirup. Also when boiling a thin layer the impurities reach the surface more easily, and by constant skimming a clear finished product is obtained. Deep boiling in such an apparatus produces the same effect as in iron kettles, namely, a dark, bad-tasting sirup. If an ordinary gutter is placed along each side of the pans when installed the scum can be raked off into this and then caught at the end in a bucket or tub. These skimmings make good food for hogs unless much lime has been added in clarification.

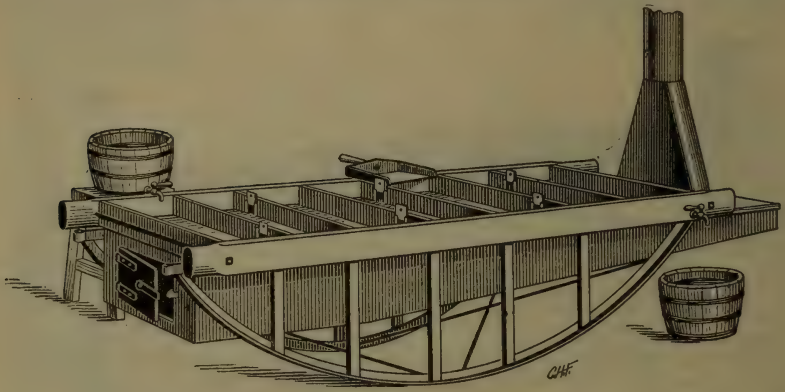


FIG. 16.—A portable evaporator.

Some makers prefer to boil to a comparatively thin sirup, pass this through a filtering medium to remove the sediment, and then reboil to a proper density. If much lime has been used in clarifying, or if the juice contains much mineral salts, some salts will deposit on concentration. Maple-sirup makers bring much of the floating mineral sediment to the top by adding to the boiling liquid the white of an egg or some whole, fresh, sweet milk, which produces a gelatinous precipitate around the small particles and brings them to the top, where they are removed by skimming. Some sorghum makers do likewise. Under most conditions this material can be removed easily by filtering through flannel or by simply allowing it to settle.

Filtering is rather difficult if the sirup is thick and gets cold; a hot liquid filters faster.

In starting a patent evaporator always have water in all the parts and boil this until the raw juice enters. Never heat kettles or pans without water unless it is desired to burn the scale loose. Even this can generally be done in other ways, namely, by boiling water in the pans, either alone or with some acid, as muriatic acid. The acid, however, must be used with the greatest care, as it dissolves the metal of the evaporator. Scraping with an iron removes the scale but it often spoils the evaporator, causing a leak at the place scraped.

USE OF STEAM EVAPORATORS.

Heating in the steam evaporator is accomplished by means of steam coils. The most common form of such evaporators is a heavy wooden box lined with some metal, as iron, tin, or copper and containing a coil of iron or copper pipe. The coil is removable so that it can be cleaned. Figure 17 shows a form of steam evaporator used to some extent; one side is for heating the juice, thereby clarifying it, and the other for the concentration. When working on a large scale, copper tanks with copper coils are used. For the small maker it is a question whether steam evaporation pays or not. Although it might pay the farmer who intends to manufacture sirup for others and make it on a large scale to use steam evaporators, fire evaporators that produce 200 gallons of sirup or more in 10 hours of boiling can be purchased. The method of operation with steam heating is the same as with the fire evaporators, but there is much less danger of burning and thereby darkening the sirup by the former process. The level of sirup should be not over half an inch to an inch above the coils for quick evaporation and a good-flavored product.

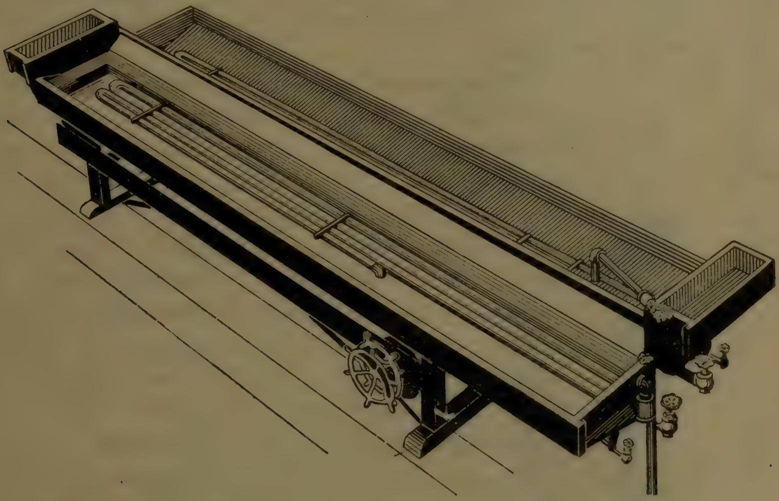


Fig. 17.—A steam evaporator.

METHODS OF DETERMINING THE FINISHING POINT.

The finished sirup upon cooling should have a moisture content of not over 30 per cent, equaling a solid content of not less than 70 per cent. One gallon of such a sirup would not weigh less than 11¼ pounds. Commercial practice recognizes this as the minimum density for a sirup. As the sirup comes from the evaporator it is rather difficult to fill and weigh a gallon measure, and again such a weight would be correct only when the whole was cooled down to about 60° F. before the weighing. Some makers determine the finishing point by pouring the sirup from a spoon and watching the last drops fall, but there are two methods which are superior and yet easy to perform. The first is noting the temperature at which the sirup is boiling and the other is to measure the density by means of a Baumé hydrometer.

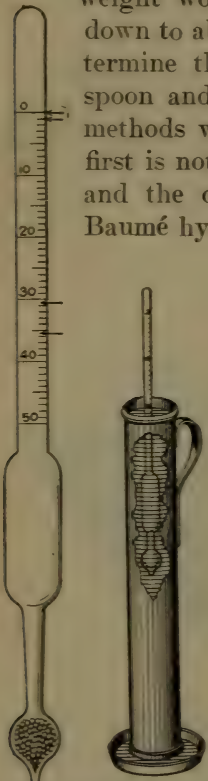


FIG. 18.—Hydrometer and its position in the liquid.

By thermometer.—As a liquid thickens, the boiling point is raised. Water at ordinary pressure or at sea level boils at 212° F., while a sugar solution with 70 per cent of solids boils at 223.7° F. If, now, a thermometer is placed in the boiling sirup one can roughly judge of the density of the product. In testing a sirup for its density by this manner it would be well to test the accuracy of the thermometer by placing it in boiling water and noting the boiling point. Then finish the sirup at a point 12° to 13° higher than the boiling point of water. Altitude affects the boiling point of liquids. For every 500 feet above sea level, roughly speaking, the boiling point is lowered 1° F., so that water at a point 2,000 feet above sea level would boil at 208° F. and a finished sirup at 220° F. In taking the temperature one must be careful not to allow the bulb of the thermometer to touch the bottom or sides of the evaporator or be exposed above the surface of the liquid; otherwise the reading will not represent the true temperature.

By hydrometer.—A hydrometer or spindle is an instrument for showing the density of a liquid. Hydrometers are graduated to various scales and for various purposes. The one generally used for rough sugar work is the Baumé. The standard of graduation is an arbitrary one, and varies somewhat with different makes. The usual Baumé hydrometer shows a graduation of zero to 50 divided into degrees, as shown in figure 18. The instrument being of glass is rather fragile. The density is measured by floating the hydrometer freely in the liquid, which is generally held in a tall cylinder, as shown in the illustration. The point on the scale where the instrument comes to rest is considered the density. With a raw juice, this varies from 4° to 8°, while for a finished sirup it should be 38° and over.

The temperature of standardization is 60° F., so for correct readings the sirup under examination should be cooled to that temperature. Sirup that gives a reading of from 35° to 36° when at boiling temperature usually gives a reading of 38° or over when it has been cooled to 60° F. The accuracy of these glass hydrometers is very much affected by using them in hot liquids; hence it is not good practice to use an accurate instrument in the hot sirup. Table 2 shows the solid content and the water content for different degrees Baumé. These figures are only approximate.

TABLE 2.—*Dry substance and water corresponding to each degree Baumé.*

Degrees Baumé.[1]	Dry substance.	Water.	Degrees Baumé.[1]	Dry substance.	Water.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	1.7	98.3	26	46.8	53.2
2	3.5	96.5	27	48.6	51.4
3	5.3	94.7	28	50.5	49.5
4	7.0	93.0	29	52.4	47.6
5	8.8	91.2	30	54.3	45.7
6	10.6	89.4	31	56.2	43.8
7	12.3	87.7	32	58.1	41.9
8	14.1	85.9	33	60.0	40.0
9	16.0	84.0	34	61.9	38.1
10	17.7	82.3	35	63.9	36.1
11	19.5	80.5	36	65.8	34.2
12	21.3	78.7	37	67.8	32.2
13	23.0	77.0	38	69.7	30.3
14	24.8	75.2	39	71.7	28.3
15	26.6	73.4	40	73.7	26.3
16	28.4	71.6	41	75.7	24.3
17	30.3	69.7	42	77.7	22.3
18	32.1	67.9	43	79.7	20.3
19	33.9	66.1	44	81.8	18.2
20	35.7	64.3	45	83.8	16.2
21	37.5	62.5	46	85.9	14.1
22	39.4	60.6	47	88.0	12.0
23	41.2	58.8	48	90.1	9.9
24	43.1	56.9	49	92.2	7.8
25	44.9	55.1	50	94.4	5.6

[1] Taken at 60° F.

It is not to be understood that a degree Baumé corresponds to 1.7 per cent of sugar, for the hydrometer measures other dissolved solids also. When determining the density of the raw juice, a reading should not be made for about 20 minutes, or until after the hydrometer has come to rest, when all the air in the juice has escaped.

TREATMENT OF FINISHED SIRUP.

When the sirup has reached the desired density it should be quickly removed from the fire and rapidly cooled. If no care in skimming has been exercised during the concentration, the sirup will have a dirty appearance, and even though carefully skimmed, there may be more or less turbidity due to suspended matter. To completely remove this in many cases is a difficult task, but allowing it to remain in the sirup spoils the appearance and to a less degree the flavor. Many methods have been proposed for removing this material. Some makers filter the sirup, some give it an extra treatment, while others allow the sirup to stand to settle the sediment. A filtration of the semisirup during concentration renders a filtration of the finished sirup unnecessary under most conditions. The greater portion of the sediment is thus removed, leaving only the mineral sediment, which is thrown down by concentrating to a higher density. Again, upon boiling a thin layer in an evaporator and carefully skimming little suspended material is left in the sirup.

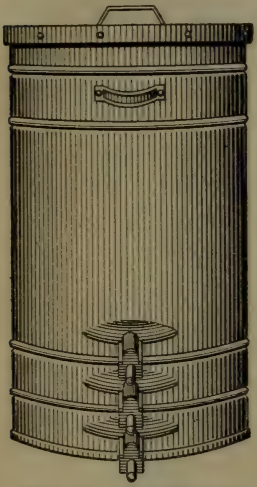


FIG. 19.—A settling can.

Sorghum sirup being particularly viscous at high concentrations does not filter easily through flannel or felt, although when worked hot it can be done. A rather coarse, sharp sand makes a good filter bed. The sand should be carefully cleaned, all organic and soluble material and clay being removed. A bed about 6 inches thick makes a filter that will generally remove the sediment. Some makers use 6 to 8 inches of excelsior or wood straw as a filtering medium. The excelsior should be soaked in hot water to remove all soluble matter before using it for this purpose. Sand or asbestos filters, or in fact any filters, should be carefully cleaned after using. All the remaining sugar solution should be washed out and the bed thoroughly sterilized with hot water or steam. When operating on a large scale, sorghum sirup can be forced through filters under pressure and the maximum cleaning in the minimum time obtained.

If the sirup is not too heavy, standing causes the sediment to collect at the bottom and the clear sirup can be drawn off. For this purpose, tall milk cans with one or two faucets placed 2 and 4 inches from the bottom serve well the purpose. Figure 19 shows such a can with three faucets. The sirup coming from the cooler can be placed in this and allowed to settle. A very heavy sirup, however, or one that is particularly viscous, may stand for as long as a week without any appreciable sedimentation taking place. If the cleansing is carefully done during the process of manufacture the finished sirup will not need much treatment.

Sorghum sirup should be quickly cooled after finishing to hold the color. Many makers run their sirup through a coil of pipe incased in cold water, which can afterwards be employed advantageously for the boiler when a power mill or steam evaporator is used. Some makers have this coil in their raw-juice tank, which serves the double purpose of heating the raw juice and cooling the finished sirup. Makers who cool their sirup quickly claim that the color is not darkened and a better grade is therefore produced.

CANNING SIRUP.

The form in which the makers offer their sirup for sale depends greatly upon the market conditions. It may be placed in tin containers with screw tops, holding one gallon, one quart, or one pint, convenient sizes for local consumption. When packing in this form, the cans should be thoroughly scalded with hot water before filling. Wooden pails and barrels of various sizes can be used. Wooden packages should be carefully washed out, and for the best after effects should receive a thorough steaming before being filled. Fermentation can be prevented by careful handling of the sirup. Sirup which has been thoroughly sterilized by boiling will not ferment if packed while hot in clean containers which have been sterilized with scalding water or steam and sealed immediately. Care should be taken to have the containers perfectly air-tight; otherwise the sterile sirups may become inoculated with the microorganisms that produce fermentation.

Sorghum sirup may be graded as to color and also flavor by establishing standards on these points and classifying the output. This is of extreme importance in supplying a local market, and it might be of value to the makers of sorghum sirup in a certain locality to unite and sell their product under such conditions. The usual buyer of such a commodity desires two purchases of the same material to have the same color and flavor. They are not informed as to why manufacturing conditions affect these and why all sorghum sirup is not of the same appearance and taste. By having such an association of farmers and a system of standardization, different products can be classified. As maple-sirup makers have found this plan of value, it might be profitably applied to the sorghum-sirup industry.

PREVENTION OF CRYSTALLIZATION.

Crystallization results from making a supersaturated solution of a substance in a liquid. In the case of sirups the sucrose becomes concentrated to a point at which it is no longer soluble in the water present, and hence it crystallizes out. This is the fundamental principle of recovering or manufacturing sugar. In these processes every care is taken to prevent the destruction of sucrose during manufacture so that a greater yield of sugar will be obtained. If sirup is the product to be made on concentration it would be natural for a crystallization to take place, and to prevent this crystallization as far as possible the following precautions are taken:

Sucrose, on being heated in the presence of an acid or on long and high heating in water, becomes broken down into two sugars. One of these is crystalline in form; the other is liquid under most conditions. These two sugars are known as invert sugar and possess a sweet taste. The modification of the process referred to is to leave the juice after clarification more acid than in ordinary work. In other words, to use less lime or none at all for clarification. On concentrating such a juice a natural inversion of the sucrose takes place, and hence there is less crystallization. This may suffice in most cases, but when the sorghum is very ripe (has a high sucrose content) the sirup may still crystallize. Some makers accomplish the desired inversion by allowing the cane to remain in the field for 24 hours or more after cutting. This practice reduces the amount of sucrose in the cane, but its effect on the flavor of the resulting sirup is a matter of conjecture. It is, however, done extensively in sorghum-sirup manufacture, and many producers state that the flavor of the sirup is not impaired by this treatment unless the cane has been cut for such a length of time that fermentation has begun. Sorghum juice as expressed from the cane contains some little starch and gummy material. If these are not removed in the process of settling and clarification, they tend to keep a sirup from crystallization, especially if the starch becomes soluble by boiling. It is not the usual policy, however, to allow them to remain in the juice for this purpose (though they are sometimes present, due to poor settling and skimming), as they influence the flavor of the sirup. The danger of crys-

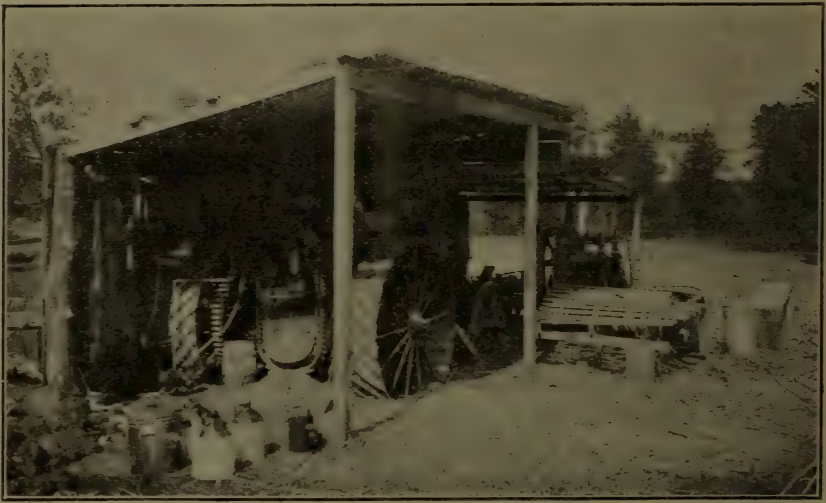


FIG. 20.—Traction engine and cane mill.

tallization in sorghum sirup is much less than in cane or maple sirup. Long standing, however, in a cool place may cause crystals of sugar to form.

ECONOMIC CONSIDERATIONS.

LOCATION AND ARRANGEMENT OF A SIRUP PLANT.

The small maker should consider carefully the location and arrangement before putting up a plant, as these points are most essential to economy in manufacture. It is impossible to enter into a very thorough discussion of this subject or to lay down hard and fast rules, as many circumstances might affect one's decision. It is certain that the boiling house, etc., should be made easily accessible for bringing in the cane and fuel and storing and taking care of the finished product. In a small plant it is not necessary to cover all the equipment. The mill should be placed on the highest level, the raw juice caught at a lower point, and the evaporator be placed lower. In this way gravity is made to play an important part. This same idea can be carried out with power mills. In manufacturing on a larger scale the mill is best placed on the ground, the raw juice is pumped into storage tanks placed higher up, from which it runs down through the clarifiers to the evaporators on the ground floor.

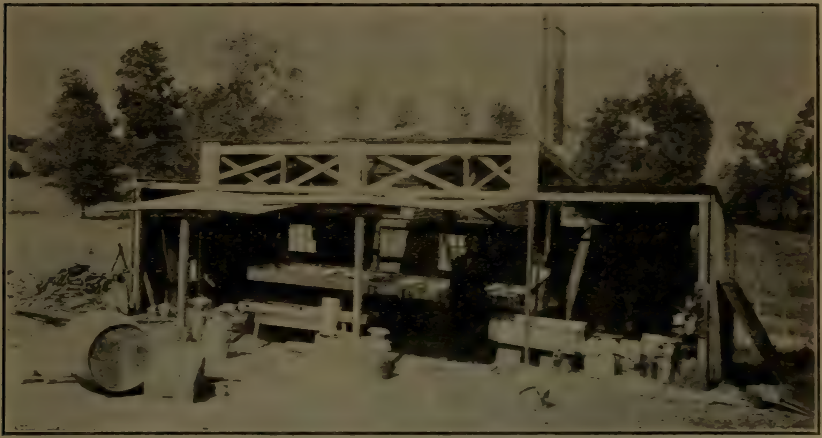


FIG. 21.—Evaporation house.

The boiling house under all conditions should be covered and provided with a good ventilator in the top to dissipate the steam, and should be inclosed on all sides to prevent the blowing of cold drafts of air on the pan, thus retarding evaporation. It is advantageous to have sections of the siding hinged at the top in such a manner as to allow them to be opened outward, as indicated in figure 21. These sections may then be regulated to facilitate the removal of steam without permitting the entrance of an undue amount of cold air. A good form for such a structure is shown in figure 21, one of the sides of the house being raised up to form an awning which when let down still allows for a passageway around the evaporator. If possible the floor of the boiling house should be paved with brick, wood, or cement, and sloped to furnish drainage. If a fire evaporator is used it would be well to have a partition at the fire door so that when stirring the fire or adding new fuel no ashes would get into the sirup. In a word, the arrangement should be such that the evaporation can be carried on with dispatch and under cleanly conditions. Many makers use their maple camps for making sorghum sirup also. The same camp and arrangements will serve admirably for the two, providing the location is convenient.

A power mill should be covered; in fact, it could well be placed in a house similar to the boiling sheds shown in figure 21, with sides capable of being raised. The evaporation house might be made large enough to hold the engine as well as the mill.

FUEL.

The fuel for the evaporation and other processes is a very important item. That one should be selected which is the cheapest for the work to be done, whether it be wood, coal, or oil. A number of makers use a crude-oil burner under their evaporators; this, in connection with a jet of steam, gives a good fire for evaporation and one capable of adjustment. Many trials have been made in using the crushed cane (bagasse) as it comes from the mills as a fuel, but a special fire box is necessary for this purpose (fig. 22).

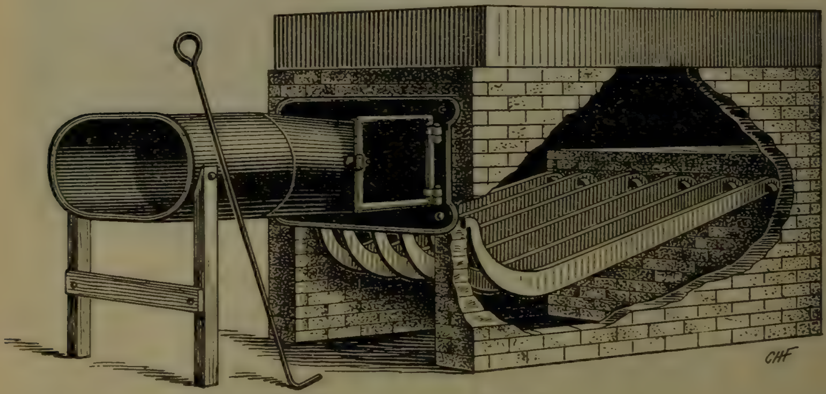


FIG. 22.—A bagasse burner.

The greatest trouble with bagasse is its high moisture content, as the usual mill does not press the cane dry, but by spreading the crushed cane out in the sun a good fuel can be obtained. In the sugar-cane industry of Cuba the bagasse furnishes in many cases from 90 to 100 per cent of the fuel for operating the whole plant; in Louisiana it furnishes from 50 to 80 per cent of the fuel. The bagasse in these two places is drier than that obtained by sorghum makers unless a series of powerful mills is used. Again, these large cane plants are equipped with special furnaces for handling the bagasse.

Figure 22 shows an arrangement for burning bagasse on a small scale under pans or evaporators. It consists of a sheet-iron funnel tapering toward the end nearest the furnace, so as to compress this light fuel slightly as it is pushed through into the furnace, and having a sheet-iron door hinged to the upper surface. This is a safer and better method of firing than to put the crushed canes directly upon the fire. A fork full of the fuel pushes the door inward, and the door closes itself when the fork is withdrawn.

Another form consists of a small oil burner in the furnace, the bagasse being fed to the fire by hand. There may be some danger, however, in this kind of firing.

MAKING SIRUP ON SHARES.

It quite often occurs that a farmer may grow sorghum but does not care to manufacture it into sirup. Upon what basis should the sirup be made? A central factory seldom raises all its own cane—it buys from the farmers. In this case the agreement is generally drawn up for the cut cane, free of trash, and either stripped or not stripped of leaves at a given price per ton of raw material. On a small scale this is seldom done, one of two general methods being followed in such cases. Either the maker produces the product at a stated price per gallon for the farmer or on shares; that is, giving the farmer a certain number of gallons of sirup (5 to 15) for each ton of cane. In either case it is necessary to keep the cane separate and the juice also, even up to the boiling if the farmer is to receive his share of sirup.

There is, however, a way of approximately determining the amount of sirup that will be made from the cane. By using this method it is not necessary to boil each lot separately, but only to grind the cane separately and then collect the raw juice in tanks where it can be measured. From the gallons of raw juice and its Baumé reading the gallons of sirup that will be made can be calculated.

The settling tanks are convenient for measuring the raw juice. If the tank is oblong or square, take the inside dimensions, length and width, in inches, multiply these together and divide the result by 231 cubic inches to obtain the gallons of juice in the tank for each 1 inch of depth. By inserting a stick or rule in the tank the number of inches of juice is obtained, and this figure multiplied by the gallons per 1 inch of depth gives the number of gallons of raw juice.

If the measuring tank is round, to obtain the gallons of juice for 1 inch multiply the diameter expressed in inches by itself (in other words, square the diameter) and then multiply this figure by 0.7854; divide the result by 231 cubic inches, and the result is the gallons of juice contained in 1 inch of height.

The other figure necessary for the calculation is the density of the juice as determined by means of the Baumé hydrometer. This instrument can be placed in the tank, provided the juice is deep enough to allow it to float freely. From these two figures the yield can be obtained. One maker, Mr. A. P. Cleland,[1] has found that 10 gallons of juice with a reading of 6° Baumé make 1 gallon of finished sirup; from this he calculated the following sliding scale:

Juice, degrees Baumé.	Gallons of juice per gallon of sirup.
6	10
6½	9
7	8½
7½	8
8	7½
8½	7
9	6½
10	6
11	5½
12	5

It is noted that the gallons of juice multiplied by the Baumé reading gives approximately 60 in each case. Each maker can and should prepare for himself such a table as his method of manufacture may not be at all like the one cited. To do this it is necessary to measure several tanks of juice and obtain their Baumé reading, then concentrate the juice to a sirup in the usual way and measure the finished sirup. By multiplying the Baumé reading of the juice by the number of gallons of raw juice and dividing by the number of gallons of finished sirup made, the figure on which to base the table (60 in the case just cited) will be found. With this beginning a table can be prepared for different Baumé readings on the raw juice. In this way as soon as a separate lot of cane is ground the juice can be measured, the density determined, and the number of gallons of sirup due the cane grower can be learned without interfering with the work of the evaporator.

EFFECT OF STRIPPING UPON SUGAR CONTENT OF JUICE.

The effect of stripping the cane is indicated in Table 3. These figures were obtained by dividing a quantity of cut cane into two portions, one of which was carefully stripped, milling the two samples in succession, and obtaining a representative sample of juice from each for analysis.

---

[1] U. S. Dept. Agr., Farmers' Bulletin 135, p. 39.

TABLE 3.—*Analyses of sorghum, stripped and unstripped, arranged according to varieties.*

Variety and condition.	Degrees Baumé.	Sucrose.	Invert sugar.	Total sugar.
Sumac:		*Per cent.*	*Per cent.*	*Per cent.*
Unstripped	7.4	4.14	7.57	11.71
Stripped	7.6	4.74	7.50	12.24
McLean:				
Unstripped	9.2	5.28	11.39	16.67
Stripped	11.1	13.76	6.66	20.42
Mixed:				
Unstripped	8.65	7.39	9.29	16.68
Stripped	8.4	9.01	6.82	15.83
Honey:				
Unstripped	6.4	2.83	7.92	10.75
Stripped	6.4	3.20	7.23	10.43
Mixed:				
Unstripped	7.9	4.57	9.02	13.59
Stripped	7.9	5.96	7.43	13.39
McLean:				
Unstripped	9.3	3.19	11.95	15.14
Stripped	10.2	12.14	4.23	16.37
Mixed:				
Unstripped	8.1	4.83	8.58	13.41
Stripped	8.0	5.73	7.63	13.36
Honey:				
Unstripped	6.2	0.22	10.50	10.72
Stripped	6.3	2.32	8.42	10.74
Average:				
Unstripped	7.89	4.06	9.53	13.58
Stripped	8.24	7.11	6.99	14.10
Average, excluding the McLean samples:				
Unstripped	7.44	4.00	8.81	12.81
Stripped	7.43	5.16	7.51	12.67

It will be noted that with each variety the percentage of invert sugar is greater in the juice from the unstripped cane than in that from the stripped cane, while the percentage of sucrose is greater in the case of the stripped cane than in the case of the unstripped. This is shown very clearly in the averages. With the exception of the McLean cane, which possessed large, heavy, green leaves, the difference between the percentage of total sugars is very slight. It seems, then, that there is no material difference in the quantity of sirup that could be produced from a given amount of juice from either stripped or unstripped cane, unless the blades are very abundant and full of juice. As noted in the section on crystallization (pp. 27 and 28), it would appear that allowing the leaves to remain tends to prevent crystallization of the sirup, due to the increased amount of invert sugar in the juice. As stated on page 10, however, allowing the blades to remain tends to make clarification more difficult and may impart a bad flavor to the juice and resulting sirup; also, when the leaves become dry more or less loss of juice through actual absorption by the dry blades during milling may occur. It is believed that where the cane is cut with the leaves still attached and allowed to remain in the field for about 24 hours, a portion of the juice of the leaves returns to the stalk as the leaves wither, with a corresponding increase in the amount of invert sugar in the juice finally obtained. For the reasons already given, however, the leaves should be removed before milling.

BY-PRODUCTS AND THEIR USES.

Bagasse.—The crushed cane as it comes from the mill is known as bagasse, the use of which as a fuel has already been discussed (p. 30). It is also of value as a fertilizer and when spread over fields and plowed under restores a certain amount of the fertilizing ingredients taken from the soil by the plant. In some sections it is customary to give cattle access to the bagasse which has been spread over the fields, care being taken not to let them eat too much of it at first. Bagasse mixed with varying percentages of cottonseed meal, molasses, etc., has also been used as a dry dairy feed. Although it has been employed as a material in making paper, its use for this purpose has not proved successful enough to warrant establishing the manufacture of paper from it upon a commercial basis.

Leaves and blades.—In stripping the cane from 5 to 15 per cent of the weight of the crop is removed; in other words, the leaves when green weigh on an average about 10 per cent of the topped cane. If they are frostbitten, or dry, or both, they may not be over 4 per cent of the weight of the cane. Some makers on buying cane consider a long ton of unstripped cane equal to a ton of stripped cane—that is, 2,240 pounds are equivalent to 2,000 pounds, which would make the leaves and dirt amount to about 12 per cent. Some varieties bear more leaves than others, so only average figures can be given. The leaves make a good cattle food, or by allowing them to remain in the fields and plowing under they are of more or less value as a fertilizer. The leaves have also been used in making ensilage. Having a tendency to become sour, however, their use for this purpose does not seem entirely satisfactory.

Seed heads.—The amount of seed per acre varies with the variety of sorghum and the stand. Estimates ranging from 5 to 30 bushels to the acre are given, an average figure for the usual varieties of sugar sorghum being about 10 bushels. They have a large feeding value, claimed by some to be equal to corn, but most authorities give them a place much below corn. On account of the shape and hardness of the seed, better feeding results are obtained by first boiling or grinding them. Because of the difficulty of removing the hulls and the astringency of the seed coating, the grain is less relished by animals than is that of the nonsaccharine varieties.

ANALYSES OF SORGHUM VARIETIES.

The results of analyses of cane grown in locations during the year 1910 are given in Table 4. The data include the Baumé reading and the percentages of sucrose and invert sugar in the expressed juice.

The samples of Collier and Coleman cane show very high percentages of sucrose with rather low invert sugar content. It is doubtful whether the average run of sorghum cane of these varieties gives such high figures, but they serve to show the results that may be expected when the cane is produced under favorable conditions.

TABLE 4.—*Analyses of sorghum, made in 1910, arranged according to varieties.*

[Results are analyses of expressed juice.]

Variety and locality.	Degrees Baumé.	Sucrose.	Invert sugar.	Total sugar.
		Per cent.	*Per cent.*	*Per cent.*
Sumac:				
Biloxi, Miss	8.1	4.07	7.37	11.44
Do	10.1	10.93	3.21	14.14
Dalhart, Tex	10.6	11.34	3.49	14.83
Do	8.6	2.88	10.90	13.78
Brownsville, Tex	9.0	8.52	4.74	13.26
Do	8.0	4.26	6.70	10.96
Planters:				
Biloxi, Miss	9.7	10.59	1.91	12.40
Arlington, Va	9.7	2.98	10.70	13.68
Do	11.3	4.15	11.69	15.85
Compton, Cal	9.7	9.27	3.28	12.55
Monette, S. C	11.6	14.47	2.84	17.31
Do	12.2	15.38	1.74	17.12
Brownsville, Tex	7.3	5.58	3.86	9.44
Do	7.9	8.22	2.05	10.27
Dalhart, Tex	8.4	4.15	5.78	9.93
Do	8.6	3.17	6.54	9.71
Red amber:				
Biloxi, Miss	9.3	9.57	2.72	12.29
Arlington, Va	9.2	0.75	12.57	13.32
Do	10.0	3.02	11.65	14.67
Monette, S. C	10.4	6.41	8.70	15.11
Compton, Cal	11.9	1.43	14.46	15.89
Dalhart, Tex	6.3	1.88	6.32	8.20
Brownsville, Tex	8.3	4.64	6.87	11.51
Do	7.4	1.81	7.64	9.45
Minnesota amber:				
Biloxi, Miss	10.7	12.89	1.72	14.61
Arlington, Va	10.0	3.54	11.15	14.69
Do	10.5	4.26	11.40	15.66
Compton, Cal	7.5	5.77	2.95	7.72
Monette, S. C	10.7	13.00	2.03	15.03
Dalhart, Tex	7.4	4.98	4.54	9.52
Do	8.5	4.82	6.78	11.60
Brownsville, Tex	7.2	5.01	4.18	9.19
Do	8.0	4.37	6.98	11.35
Orange:				
Biloxi, Miss	10.3	12.32	1.88	14.20
Arlington, Va	8.1	2.86	7.35	10.21
Do	10.5	1.66	14.62	16.28
Compton, Cal	9.2	7.99	3.38	11.37
Monette, S. C	....	14.30	1.75	16.05
Do	12.7	15.53	2.14	17.67
Dalhart, Tex	6.2	1.70	5.72	7.42
Brownsville, Tex	6.8	2.64	5.91	8.55
Do	9.6	8.14	5.35	13.49
Honey:				
Biloxi, Miss	8.6	8.22	4.44	12.66
Arlington, Va	11.0	3.58	13.57	17.15
Do	11.2	11.46	4.48	15.94
Compton, Cal	11.6	12.59	1.50	14.09
Dalhart, Tex	9.7	1.73	11.97	13.70
Brownsville, Tex	8.3	5.66	5.78	11.44
Do	8.7	8.44	3.42	11.86
Gooseneck:				
Biloxi, Miss	8.9	8.67	4.42	13.09
Arlington, Va	8.7	3.84	8.80	12.64
Compton, Cal	8.5	7.39	2.91	10.30
Dalhart, Tex	10.5	10.48	4.63	15.11
Colman:				
Compton, Cal	11.9	13.79	1.12	14.91
Monette, S. C	....	15.30	1.28	16.58
Do	11.2	14.25	1.93	16.18
Collier:				
Compton, Cal	10.9	12.14	2.12	14.26
Monette, S. C	13.7	18.39	0.61	19.00
Do	14.0	18.24	0.92	19.16
Average	9.6	7.61	5.61	13.22

STATISTICS.

The figures in Table 5 were obtained from the United States Census reports. These figures are only approximately accurate, as it is quite impossible to obtain exact data owing to the fact that much of the sorghum sirup is made upon a very small scale and probably not reported. If such sirup were included, the totals would be greater.

It will be noted that a maximum yield of nearly 28,500,000 gallons was produced in 1879 and that the yield has steadily decreased, approximately 16,500,000 gallons having been produced in 1909. The production in some States has decreased rapidly since 1879, as, for instance, Iowa, Illinois, Missouri, Ohio, and Kansas, while in other States—Kentucky, Tennessee, Arkansas, North Carolina, and Texas—it appears to remain about the same. The production in 1909 shows an increase over that of 1879 in comparatively few States, namely, Oklahoma, Texas, Florida, New Mexico, California, Nevada, Montana, and North Dakota. Arkansas and North Carolina also show an increase, though not so great a one as in 1889 and 1899. The nonproduction of sorghum sirup in Maine, New Hampshire, Vermont, Massachusetts, and Connecticut, and the marked decrease in production in New York, Pennsylvania, Ohio, and Michigan is probably due to the fact that all of these States are large producers of maple sirup and sugar.

TABLE 5.—*Gallons of sorghum sirup produced (United States Census reports).*

States.	Year of census report.					
	1909	1899	1889	1879	1869	1859
Kentucky	2,733,683	1,277,206	2,094,962	2,962,965	1,740,453	356,705
Tennessee	2,076,339	2,047,655	2,542,533	3,776,212	1,254,701	706,663
Missouri	1,788,391	1,990,987	2,721,240	4,129,595	1,730,171	796,111
Arkansas	1,140,532	1,223,691	1,868,952	1,118,364	147,203	115,604
North Carolina	1,099,346	1,419,570	1,268,946	964,662	621,855	263,475
Illinois	977,238	625,939	1,110,183	2,265,993	1,960,473	806,589
Indiana	965,086	579,061	751,808	1,741,853	2,026,212	881,049
Alabama	809,361	1,168,868	1,242,689	1,163,451	267,269	55,653
Georgia	740,450	767,024	1,342,803	981,152	374,027	103,490
Mississippi	622,356	1,162,269	972,216	1,062,140	67,509	1,427
West Virginia	604,201	450,777	512,747	817,168	780,829	....
Oklahoma	514,807	179,272	31,299	....	....	....
Texas	448,185	877,232	1,749,910	432,059	174,509	112,412
Virginia	441,189	555,321	546,328	564,558	329,155	....
Ohio	354,131	341,523	547,630	1,229,852	2,023,427	779,076
South Carolina	262,452	478,190	559,216	281,242	183,585	51,041
Kansas	260,680	735,787	1,484,937	1,429,476	449,409	87,656
Iowa	250,205	521,212	1,386,605	2,064,020	1,218,636	1,211,512
Minnesota	145,934	157,605	340,792	543,369	38,735	14,178
Wisconsin	139,667	160,414	219,070	314,150	74,478	19,854
Louisiana	47,029	48,727	107,763	33,777	180	....
Florida	22,177	....	10,461	10,199	....	....
Utah	21,847	28,017	24,293	58,221	67,446	25,475
Michigan	21,350	24,059	45,524	102,500	94,686	86,953
Nebraska	14,644	92,413	634,146	246,047	77,598	23,497
New Mexico	5,289	2,812	3,510	251	1,765	1,950
Delaware	4,517	8,952	3,371	25,136	65,908	1,613
California	4,330	8,671	1,670	2,459	333	552
Arizona	3,967	9,031	4,808	5,771	....	....
Pennsylvania	2,585	6,514	33,708	69,767	213,373	22,749

TABLE 5.—*Gallons of sorghum sirup produced, etc.*—Continued.

States.	Year of census report.					
	1909	1899	1889	1879	1869	1859
Colorado	2,547	2,661	19,964	3,227		
South Dakota	2,030	9,859	29,372			
Maryland	1,782	4,058	4,732	19,837	28,563	907
Oregon	1,374	2,473	2,706	2,283		315
Nevada	1,266	1,465	930	350	3,651	
Washington	634	438	1,125	1,472	612	
Idaho	407	1,393	3,093	36		
Montana	223	100				
North Dakota	102	114	10			
New Jersey	35	450	281	1,261	17,424	396
New York	14	973	8,305	1,134	7,832	516
Wyoming			120			
Connecticut			214	1,163	6,832	395
Maine			152			
New Hampshire			50			
Vermont			45			
Massachusetts				18		
Total United States	16,532,382	16,972,783	24,235,219	28,444,202	16,050,089	6,749,123

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO THE PRODUCTION OF SIRUP.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Production of Maple Sirup and Sugar. (Farmers' Bulletin 516.)

Uses of Sorghum Grain. (Farmers' Bulletin 686.)

Muscadine Grape Sirup. (Farmers' Bulletin 758.)

Sugar-Beet Sirup. (Farmers' Bulletin 823.)

Maple-Sap Sirup: Its Manufacture, Composition, and Effect of Environment Thereon. (Bureau of Chemistry Bulletin 134.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Manufacture of Table Sirup from Sugar Cane. (Bureau of Chemistry Bulletin 70.) Price, 10 cents.

Experiments in Culture of Sugar Cane and its Manufacture Into Table Sirup. Report on Investigations Conducted at Waycross and Cairo, Ga., in 1903 and 1904. (Bureau of Chemistry Bulletin 93.) Price, 20 cents.

Experimental Work in Production of Table Sirup at Waycross, Ga., 1905. Together with Summary of Four-Year Experiment on Fertilization of Sugar Cane. (Bureau of Chemistry Bulletin 103.) Price, 10 cents.

Suggested Modification of Winton Lead Number, Especially as Applied to Mixture of Maple and Cane Sirups. (Bureau of Chemistry Circular 53.) Price, 5 cents.

Sugar Cane Culture for Sirup Production in the United States. (Department Bulletin 486.) Price, 10 cents.

Kaoliangs, New Group of Grain Sorghums. (Bureau of Plant Industry Bulletin 253.) Price, 15 cents.

Utilization of Waste Raisin Seed. (Bureau of Plant Industry Bulletin 276.) Price, 5 cents.

CONTENTS.

	Page.
Introduction	5
History of sorghum	6
Varieties of sorghum	6
Amber sorghum	7
Orange sorghum	7
Sumac or red-top sorghum	8
Gooseneck sorghum	9
Honey sorghum	9
Selection of a variety	9
Culture of sorghum	10
Preparing the seed bed	10
Planting	11
Cultivation	12
Harvesting	12
Manufacture of sorghum sirup	14
Extraction of the juice	14
Settling tanks	16
Clarification	19
Heat alone	20
Heat and lime	20
Other methods of clarification	21
Test glass and its use	21
Evaporation or concentration	22
Use of kettles	22
Use of pans and patent evaporators	23
Use of steam evaporators	26
Methods of determining the finishing point	26
By thermometer	26
By hydrometer	27
Treatment of finished sirup	28
Canning sirup	29
Prevention of crystallization	30
Comments by representative sirup makers	31
Economic considerations	33
Location and arrangement of a sirup plant	33
Fuel	35
Making sirup on shares	36
By-products and their uses	38
Analyses of sorghum varieties	39
Statistics	40

ILLUSTRATIONS.

	Page.
FIG. 1. A head of amber sorghum	7
2. A head of orange sorghum	8
3. A head of sumac sorghum	9
4. A head of gooseneck sorghum	10
5. Heavy three-roller vertical horsepower cane mill	15
6. Three-roller horizontal horsepower cane mill	16
7. Three-roller power mill	17
8. Mill with feed table and bagasse carrier	18
9. Feed cooker for heating juices	18
10. A swinging barrel for easily pouring off settled juice	19
11. Tank connections for drawing off juice	19
12. Test glass with cut of handle	22
13. Jamaica train of kettles	22
14. A sirup skimmer	23
15. A pan evaporator	23
16. A portable evaporator	24
17. A steam evaporator	25
18. Hydrometer and its position in the liquid	27
19. A settling can	29
20. General view of sorghum sirup plant	34
21. Traction engine and cane mill	35
22. Evaporation house	36
23. A bagasse burner	37

SORGHUM SIRUP MANUFACTURE.

INTRODUCTION.

When the extension of the sorghum industry was first advocated it was thought that this crop would play a notable part in supplying the nation's sugar on account of its wider distribution than sugar cane or sugar beets, its large yield per acre and ease of cultivation, and its rather high sucrose content. After many trials, however, it was found that the juices, although rich in sucrose, contained some reducing sugars and also quite a large percentage of gums and gummy material which on concentration prevented crystallization. After these experiments were made the question of using sorghum for sugar and sirup manufacture was dropped to a great extent until more recently, when the manufacture of sorghum sirup has been in a measure revived. This is true particularly in the regions where maple sirup was formerly made in notable quantities as well as in the old sorghum States, and has been brought about in part by the depletion of the maple forests, and by the scarcity of old-time cane sirup and molasses and also by the fact that with patent evaporators a good, light-colored sorghum sirup with a pleasing taste can be obtained.

Although the terms "sirup" and "molasses" are often used interchangeably in connection with sorghum, they refer to altogether different products. Sorghum sirup is the concentrated juice of the sorghum plant with or without the addition of the usual clarifiers, while sorghum molasses is the liquid residue coming from the draining or centrifugaling of sorghum sugar. As very little, if any, sorghum sugar is manufactured to-day, the product of farm manufacture could hardly be termed "sorghum molasses." This confusion of terms may be due in part to the fact that molasses is generally heavy and thick, while sirup is lighter and thinner and ordinary sorghum sirup is heavy in appearance, due to the gummy material present, resembling molasses more than it does a maple or cane sirup of equal density.

The manufacture of sorghum sirup is not a complicated process requiring special skill. It does not necessarily call for expensive apparatus or machinery nor are dangerous chemicals employed. The processes to be described are simple, but as in all sugar or sirup making cleanliness and dispatch are necessary, and unless one is very careful, numerous unsuccessful trials may be made before a fine sirup is produced.

HISTORY OF SORGHUM.

Under sorghum, in the broad sense of the word, are included all the groups popularly known in this country as sorgo, sweet sorghum or saccharine sorghum, kafir, broom corn, shallu, kowliang, durra, and milo, but only the first group is of practical interest. Carleton R. Ball has given an extensive account of The History and Distribution of Sorghum in Bulletin No. 175 of the Bureau of Plant Industry, United States Department of Agriculture. It appears that sorghum originally grew wild in all tropical and subtropical parts of the Old World. In Beni-Hassan, Egypt, on the tomb of Amenembes, belonging to the dynasty existing at least 2,200 years before Christ, is frescoed a harvest field which is said to represent sorghum. In the book of the prophet Ezekiel (600 B. C.) is found the word "dochan," translated "millet," which word is still used in Arabic for forms of sorghum. As civilization moved westward the sorghum was carried with it, but no statements are to be found in the literature showing that the ancient cultivators knew that sorghum was a sugar-producing plant and it was in this country that the first efforts to manufacture sugar and sirup were made.

The credit of first growing sweet sorghum in the United States belongs to a nurseryman, William R. Prince, of Flushing, N. Y., who, in 1853, grew a variety of Chinese sorgo which came from France.[1] In 1855 the United States Commissioner of Patents distributed a small quantity of seed secured in France and the next year the first wide distribution of seed was made by the United States Government. In 1857 about 16 varieties of African sorghum were introduced and grown in Georgia and South Carolina. As a class they were called "imphee," a name found in many of the older works on sorghum, and often applied to certain varieties by some of the older growers. In 1865 four more varieties were received from China and in 1880 a large number of varieties were imported, both from China and from Natal.

VARIETIES OF SORGHUM.[2]

Saccharine sorghums are recognized by their sweet sap or juice. They are, as a rule, tall with a leafy growth, branching only sparingly at the upper nodes or joints, and not stooling much at the base under ordinary cultivation. The seed head varies from the close compact "club" head of the Sumac sorghum through the rather more open heads of Orange and Gooseneck, to the loose and often widely spreading heads of the Amber and Honey varieties.

---

[1] U. S. Dept. Agr., Bureau of Plant Industry Bul. 175, p. 32.

[2] The notes and description of varieties are taken in part from Farmers' Bulletin No. 246, entitled "Saccharine Sorghums for Forage," by Carleton R. Ball.

Beginning with the original importation of a single variety of Chinese origin in 1853, there were in 1906 probably no less than 200 so-called varieties in cultivation. Most of them, however, never attained any prominence outside of the locality where they originated. Ball has divided the sweet-sorghum varieties into three or four groups, each consisting of a single well-marked variety and a number of forms derived from it. Such groups are the Amber, Orange, Sumac, and Gooseneck sorghums.

AMBER SORGHUM.

Amber sorghum is said to have developed in Indiana from the original Chinese sorghum. It is an early variety and is sought for that reason. It soon was called Early Amber, and when the seed came from Minnesota was known as Minnesota Early Amber. In Bailey's Encyclopedia of American Agriculture, the latter variety is said to have originated through selection by Seth H. Kenney. From 70 to 100 days are necessary for the Amber sorghum to reach maturity, the time varying according to the latitude, season, and soil. It is characterized by the rather slender stalks and comparatively few and narrow leaves; the seed heads are generally black in color, varying considerably in shape and size, and rather loose, as is shown in the cut (fig. 1). One variety of this Early Amber is known as Folger and is a strain originated as an improved sirup variety having all the characteristics of Amber sorghum. Other varieties of some prominence are the Red Amber and the Minnesota Amber.

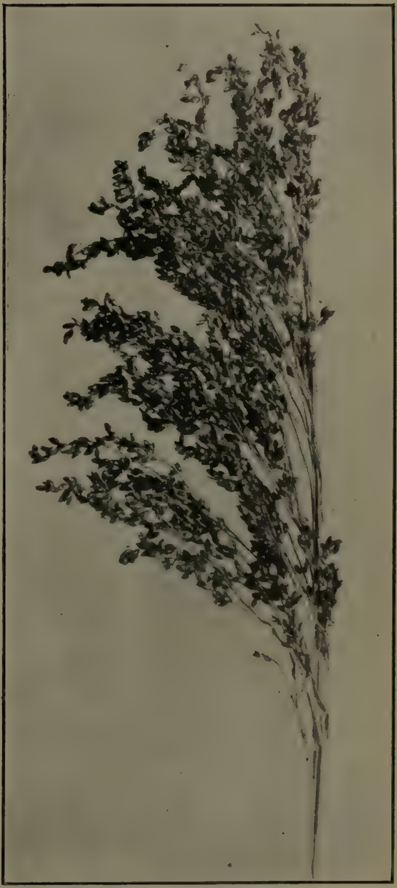


FIG. 1.—A head of Amber sorghum (about one-fourth natural size).

ORANGE SORGHUM.

Orange sorghum is of South African origin and differs from the Amber variety in having larger and heavier stalks, larger and more abundant leaves, and heavier and more compact seed heads (fig. 2). The seeds just before ripening are almost white. The Early Orange, as this standard variety is usually called, requires about two or three weeks longer than the Amber to reach maturity. On account of its growing taller and the stalks larger, it gives a slightly heavier yield per acre. Various forms of this variety are offered on the market, including Kansas Orange and Late Orange.

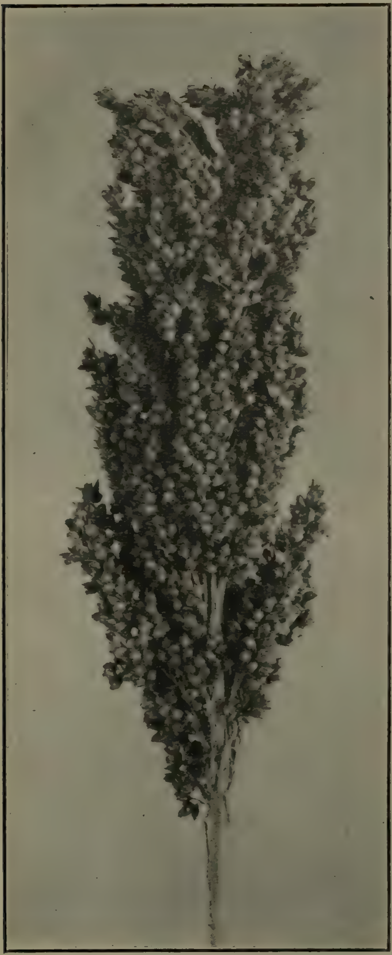


FIG. 2.—A head of Orange sorghum (one-half natural size).

The Colman variety, which is said to have originated as a hybrid between Early Amber and Orange sorghum, is used by many for sirup making and has been shown at times to give a juice richer in sugar than any other (see p. 40 for analyses of this variety). In size, character of the seed head, and time required for maturity it is almost identical with Orange sorghum.

Another variety that was formerly grown extensively for sirup was the Collier, which when first introduced and given its name was a distinct variety, quite different from Orange, but the pure Collier seems to be no longer grown (see p. 40 for analyses).

SUMAC OR RED-TOP SORGHUM.

Sumac or Red-Top sorghum may quite certainly be identified with the varieties brought from Natal. It is a stout, stocky variety with an abundance of large, broad leaves; the seed heads are stout, thick, cylindrical and erect, and the reddish-brown seeds are the smallest of any (fig. 3). This variety grows from 7 to 10 feet high, according to its environment, is usually of a very even growth throughout a field, and matures rather early, requiring from 90 to 120 days. It is cultivated quite extensively in the South.

GOOSENECK SORGHUM.

Gooseneck sorghum is distinct from any of the others grown in this country and is thought to be a direct descendant from one of the original African varieties. Its name is probably derived from the recurved and pendent stems, reddish in color (fig. 4). It grows commonly from 10 to 12 feet high and when thinly sown, for sirup making, the stalks are from 1 to 1½ to 2 inches in diameter at the butt. This variety was extensively grown in the South, especially Texas, but being a much later ripener than Amber and a week or 10 days later than Orange and Sumac, it can not be grown in the Northern States.

HONEY SORGHUM.

Another variety of some prominence is the Honey. Its origin can not be definitely traced, but no doubt it came from an African importation. The stalks are from 7 to 10 feet high, averaging 13 to 18 nodes in different localities, are stout, from 1 to 1½ inches in diameter at the base, and very sweet. The stems are markedly tender in comparison with other stout varieties. It is, however, a very late ripener, requiring from 130 to 140 days to mature, and therefore is best adapted to the South.

SELECTION OF A VARIETY.

From the preceding discussion it is seen that for northern regions, where the growing season is short, some form of Early Amber or of Early Orange, preferably the former, must be selected, while farther south all the varieties may be used. A variety grown one season may produce a good sirup, but under different climatic conditions another year may not yield so good a product. The nature of the season seems to exert a marked influence on the composition of the plant, as has been definitely determined in the case of other sugar-bearing crops. It is to be regretted that the systematic work in the selection of a sorghum for sirup and sugar making, begun about 1890, was not carried out, as many facts were being brought

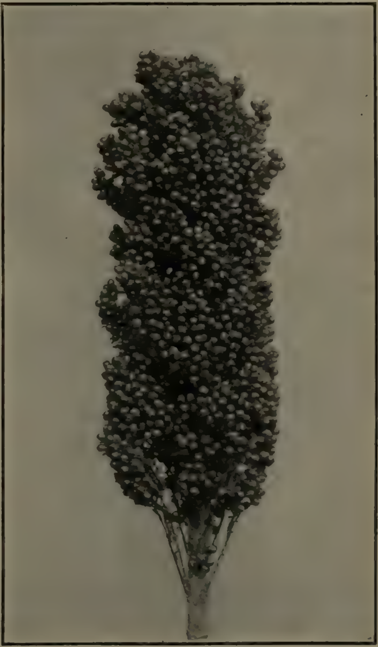


FIG. 3.—A head of Sumac sorghum (one-third natural size).

forth and a strain of sorghum rich in sucrose and low in reducing sugars was being propagated.[1] However, this subject is being revived and it is hoped that valuable data may be obtained.

When a variety has repeatedly given good yields and a good quality of sirup, the seed should be carefully selected for replanting. To do this, place several typical canes[2] in shock, cover them with a net or other protection from birds, and when quite dry cut the seed heads and place them in a stout grain bag. The seed can be thrashed by pounding with a club and cleaned by pouring from one pan to another in a gentle breeze. Stems and trash can be removed from the seed by shaking the pan and picking them out as they come to the surface. In this way an unmixed seed of good quality can be obtained by the sirup maker.

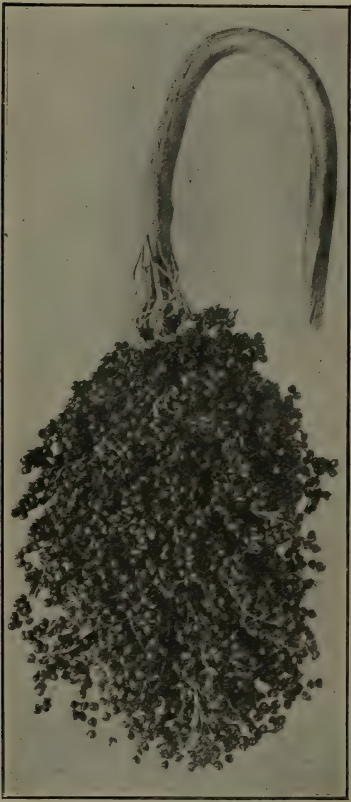


FIG. 4.—A head of Gooseneck sorghum (one-third natural size).

CULTURE OF SORGHUM.[3]

While sorghum is a crop that is generally thought to require little attention, its yield and value can be materially increased by using care in its culture. Good seed of the right variety is necessary for the best yields, but there are other equally important factors that must not be neglected, such as preparation of the soil, time and rate of seeding, and manner of planting. Perhaps more failures to get satisfactory crops are due to improper seeding than to any other cause, and too great care can not be given to planning for and planting the crop.

PREPARING THE SEED BED.

Although a large portion of the land planted to sorghum is left unplowed until a short time before seeding, this practice is by no means advisable. For the best yields there must be a firm seed bed, obtained by plowing the land early in the fall and harrowing or disking to keep down weeds until seeding time. Such preparation allows whatever vegetation there may be in the soil to decay and leaves it in the best tillable condition. In the drier regions this treatment serves to take in and retain any moisture that may come during the winter season and to decrease the chance of failure from drought. In the same manner it increases the yield in more favorable seasons. In the more humid sections early preparation is preferable, though not so necessary as in the drier regions. The land is sometimes prepared by "bedding" or listing with a middle buster or a turning plow.

---

[1] U. S. Dept. Agr., Bureau of Chemistry Bul. 40 contains a summary of this work.

[2] Comparison of the size of seed head and sugar content of stalk has led to the generalization that individual cane with larger seed heads than their fellows have a lower content of sugar. (A. A. Denton) U. S. Dept. Agr., Bureau of Chemistry Bul. 26, p. 94.

[3] This section was prepared by A. B. Connor, Bureau of Plant Industry.

PLANTING.

The planting of sorghum deserves more careful attention than any other operation entering into the production of the crop. The time, method, and rate of seeding mean success or failure in the degree in which it has been properly or improperly done. It is therefore of vital importance that the farmer attend carefully to the planting of his crop.

Time of planting.—The sorghums are usually planted soon after corn, when the ground is thoroughly warm. They may be planted at any time after that date until as late as will permit the crop to mature safely. In the Southern States the first of April is considered early planting. Northward, using the northern line of Louisiana as a base, the season gets later at the rate of about one week for every 2 degrees, or 150 miles. Early seeding is preferable for the reason that it may produce a second crop which can be used for forage. It is usually well to make two or three different plantings at intervals of about ten days or two weeks so as not to have all the crop mature at the same time.

Method of planting.—For sirup production sorghum should always be planted in rows 3 or 3½ feet apart. This may be done with a single or double row planter either on a bed, on the surface, or in a lister furrow, as is most advisable, depending on the section where the crop is grown. Furrow planting is most common in the drier regions, but it is practiced to some extent in the humid sections. In some of the lower and poorly drained lands planting is made on a bed, but only under such conditions should this method be used.

Rate of seeding.—The rate and regularity of seeding largely influence the yield of sirup regardless of the method used. Seeding should be done so that the plants will be very evenly distributed and average a distance of 4 to 6 inches in the row, or even thinner in the drier regions. A special plate for the drill can be made that will plant the crop very satisfactorily and thus avoid a great deal of labor in thinning. A very small quantity of seed is required to plant an acre, at most not more than 1 or 2 pounds.

CULTIVATION.

While sorghum will grow and give fair yields with little or no cultivation, this is by no means the most profitable method of producing the crop. Careful cultivation has repeatedly been known to increase materially the yield per acre. The first cultivation can be given with a spike-toothed harrow, and as soon as possible afterward it should be cultivated deeply with sweeps or shovels. Later in the season at least two additional shallower cultivatings should be given for the best results. Sorghum can be cultivated to advantage until it begins to put out heads, provided care is taken not to destroy the surface feeding roots.

HARVESTING.

The stage at which the sorghum contains its greatest sugar content, a matter of the greatest importance to the sirup maker, has been the subject of much investigation in former years. Collier gave the following figures as a result of about 2,740 analyses of sorghum canes made at different stages of growth:

Sugar content of sorghum at different stages of growth. (*Peter Collier.*)

Stage of cutting.	Sucrose.	Invert sugar.
	Per cent.	*Per cent.*
Panicles just appearing	1.76	4.29
Panicles entirely out	3.51	4.50
Flowers all out	5.13	4.15
Seed:		
In milk stage	7.38	3.86
Doughy, becoming dry	8.95	3.19
Dry, easily split	10.66	2.35
Hard	11.69	1.81

From these figures it appears that from the time the seed is in the late milk stage until it is becoming dry, the cane is in the best condition for sirup making. Some prefer to wait until the seed is hard before cutting, as the sugar content is still higher then, but they run the danger of a frost before all of the cane is worked up.

Cutting can be done by hand or by a harvester. When harvested by hand, the individual canes are cut about 6 or 8 inches above ground and laid across the rows with the heads all in the same direction. With a harvester and binder the cutting and binding in bundles forms one operation, and the seed heads are all at one end of the bundle. It is customary among some makers to leave the hand-cut cane in the field for a day or two to wilt the leaves, which is said to improve the quality of the sirup. The seed heads are removed and left in the field to be collected after the harvest. In making a good grade of sorghum sirup it is necessary to remove all leaves and seed heads from the cane, as these on passing through the mill give the juice and the resulting sirup a bad flavor and also make clarification more difficult. In removing the seed heads, about 6 to 18 inches of the upper cane should be cut off, as this part contains little sucrose and many impurities; suckers should also be discarded for the same reason.

The harvesting should progress in proportion to the mill work, no more being cut at one time than can be worked in two days. When the weather is cold the cane may be cut and shocked. Some makers have kept it in stock for four weeks with no appreciable loss in sirup-making properties. Like other sugar-producing plants, however, a freeze does not hurt the crop, provided the cane can be worked up just as soon as it thaws. On freezing, the cells of the cane are broken; and on thawing, decomposition quickly sets in. A frost will not hurt a ripe cane materially, but if the cane is immature it will be spoiled. Frosted cane, like frozen cane, should be worked up as soon as possible. In Louisiana the sugar cane is "windrowed" when a frost or freeze is expected—that is, the cane is cut and laid on the ground between the rows, the leaves serving as a protection. In the case of sorghum, under such conditions, if the weather is warm during the middle of the day, the leaves on the stalk soon produce a "heating" of the pile and decomposition sets in. "Heated cane" and frosted cane do affect the flavor of the sirup. One of the large makers states that by shocking the cane with leaves and heads on, he has kept it in good condition for many weeks. This, of course, was during cool weather, for even when standing in shocks the cane is liable to "heat."

As stated before, for sirup making the best stage for cutting is just before hardening of the seed. Earlier than this the cane is too green and the resulting sirup will have an unripe taste. If cut when the seeds are very hard, the juice is said to be difficult to clarify, and the flavor of the sirup is not good.

On the subject of yield, but few definite data can be given, as so many factors influence it. Sorghum may yield as high as 15 tons to the acre or as low as 4 or 5 tons; an average crop is about 8 or 10 tons. The gallons of sirup per ton of sorghum depends on the kind of mill and on the care in manufacture, also the ripeness and kind of cane. A ton of cane with a 3-roller mill should yield anywhere from 700 to 1,200 pounds of juice, giving 8 to 30 gallons of finished sirup, depending upon the richness of the juice. Or, in other words, one should obtain from 60 to 300 gallons of sirup per acre, a fair average figure being between 100 and 150 gallons. There are large losses of juice in the mills and again in skimming.

MANUFACTURE OF SORGHUM SIRUP.

A few well-defined steps in the manufacture of sorghum sirup will be considered under the following heads: (1) Extraction of the juice; (2) Clarification of the raw juice; (3) Evaporation of the juice; (4) Bottling or canning of the sirup; (5) Utilization of the waste. Under these different headings many subheads are made for a clearer understanding of the procedure. At this point it might be well to say that the discussions entered into are more for the benefit of the small makers of sirup than for those having large, well-equipped plants.

EXTRACTION OF THE JUICE.

The ordinary method of obtaining juice from sorghum cane is by pressure—that is, running the cane between iron rollers set at a certain distance apart. Another method is by diffusion, a process in which the cane is first finely shredded and placed under pressure with water in large tanks, the water removing the sugar and soluble material. This method requires very expensive machinery and much experience, and is not used now by any sorghum-sirup makers, although it is the ordinary process used for extracting the sugar from beets.

The primitive mills were made by placing two logs upright side by side in a heavy frame. To one of the logs, extending above the frame, was attached a large sweep. On turning this and feeding the cane between the rollers, the juice was squeezed out. This kind of mill is used now to a very limited extent. It does not extract more than 25 or 30 per cent of the juice, and hence has little commercial value. The wooden rollers of this form have been replaced by iron rolls, and to-day many makes of 2-roller mills are found on the market. The extraction with these is better than with the wooden rollers, but does not equal that of the 3-roller mill. The latter can be obtained with the rolls upright or horizontal. The smaller mills are operated by horses or mules, the larger ones by steam or water power. Figure 5 gives a view of a 3-roller upright mill with a shaft for a sweep operated by horsepower. Figure 6 shows a 3-roller horizontal mill for horsepower. These mills can be provided with smooth or serrated rolls. In the upright position the serrated rolls prevent the cane from twisting to one side. A good mill should be easily taken apart and new pieces substituted when breaks occur; it must run smoothly and true for good results. The rolls must be capable of being adjusted to any distance from each other. In setting up such mills, care should be exercised to have the mill level and rigid on the frame or upright supports, which should be carefully braced. Without these precautions, imperfect pressing will result and a break in the mill be caused. Figure 7 shows a power mill. These are made either single or double geared, so that they can be connected direct with some form of farm engine. Figure 21 (p. 35) shows a power mill driven by a traction engine. Power mills are certainly to be preferred to the horse mills, as the crop can be worked up more easily and quickly. Figure 8 shows a power mill fitted with a feed table and a bagasse carrier. The former is an important adjunct to a milling outfit, especially for a power mill, as it allows the cane to be arranged in some order before entering the rolls, thereby assuring a more even feed. A bagasse carrier geared to the rolls delivers the bagasse some distance from the mill.

In making sorghum on a large scale, two 3-roller mills may be used, one following the other. In this case, the crushed cane (bagasse) as it comes from the first 3-roller mill is often moistened slightly with water and then passed immediately into the second mill. This method increases the extraction considerably.

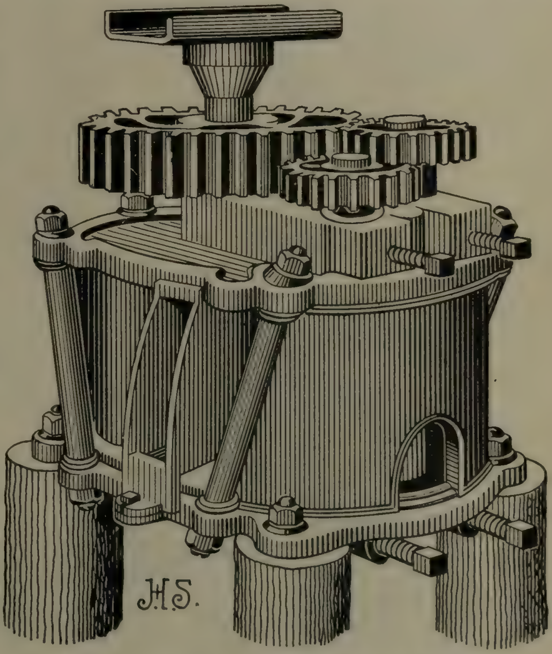


FIG. 5.—Heavy three-roller vertical horsepower cane mill.

Having selected a mill and set the rolls, the next point to consider is how to feed the mill so as to obtain the best results from the cane. Sorghum ordinarily contains from 70 to 80 per cent of water and about 10 to 12 per cent of fiber, but it is not possible to obtain all of the water as juice. With a 3-roller mill, at least 50 per cent of the weight of the cane should be obtained as juice unless the cane is very hard and dry, and with a good mill and close setting 60 per cent is not too much to expect. The "feed," or amount of cane in the mill at one time, should be light or heavy according to the adjustment of rolls. When the rolls are set "open" or apart the feed should be heavy; when they are set close together the feed should be light; but in all cases it should be regular and uniform. It is evident that when the rolls are set "open" there is a waste of juice when the feed is light; with a close-set roll there is also a loss of juice when the feed is irregular and not even over the roll.

Juice obtained by moderate pressing is purer than that obtained by extreme pressure, for under the latter condition not only more juice but also more impurities from the rind and joints of the cane are extracted. Sirup made from moderate pressing is generally better flavored than that from the heavy pressing. Where cane is cheap and abundant it is inadvisable to increase the extraction of the juice greatly by excessive pressure.

SETTLING TANKS.

The raw juice coming from the mills should pass into collection or storage tanks. These may be merely rough barrels or metal or concrete tanks. The raw juice before entering these should pass through a fine sieve or mesh screen to remove particles of cane, dirt, etc. There should be at least two tanks, one being filled while the other is emptied. A third tank is almost a necessity as it allows time for the juice to settle. Raw sorghum juice holds mechanically in solution a number of impurities which on standing will slowly settle to the bottom and if not allowed to settle they will collect in the evaporator at the point of entrance of the raw juice and may burn on the bottom of the evaporator. It is necessary, therefore, to remove as much as possible of this material before evaporation is begun. Heating the raw sorghum juice tends to quicken the settling of the juices. Some makers use a small boiler or feed cooker (fig. 9) for this purpose; especially is this done when the evaporation is carried on by direct fire. Where steam evaporation is used, the exhaust may be used to heat the raw juice.

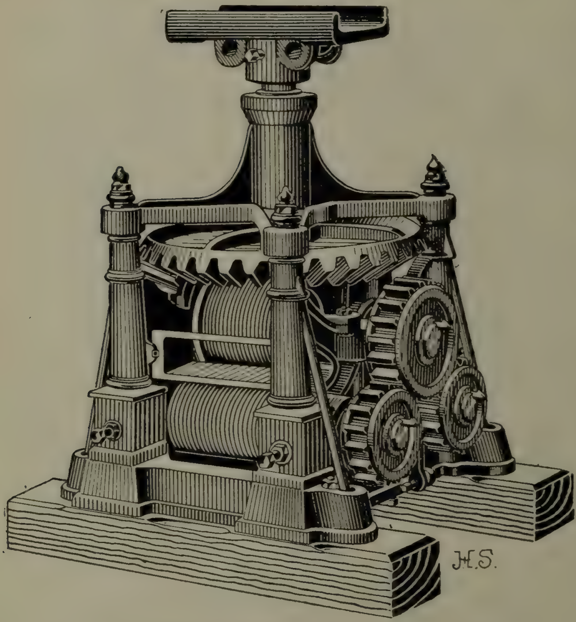


FIG. 6.—Three-roller horizontal horsepower cane mill.

Other makers settle this material by means of clay added to the cold or hot raw juice. A. A. Denton [1] proposed that a heavy, finely divided clay be stirred in with the juice. This tends to surround the floating sediment and carry it to the bottom, but it requires the use of a heavy, coarse-grained clay, which is often not easily obtainable. An examination of some 200 samples of clay,[2] collected from all over the country, showed in general: (1) That fire clays are too coarse grained and do not carry down the impurities; (2) that pure white clays are too fine grained and give bulky and indistinct settlings; (3) that blue clays, gumbo, or waxy clays are not suitable; and (4) that yellow or brown plastic clays are best. Still other makers pass the raw juice through filtering bags to remove the sediment, but this is rather tedious and does not always accomplish the purpose.

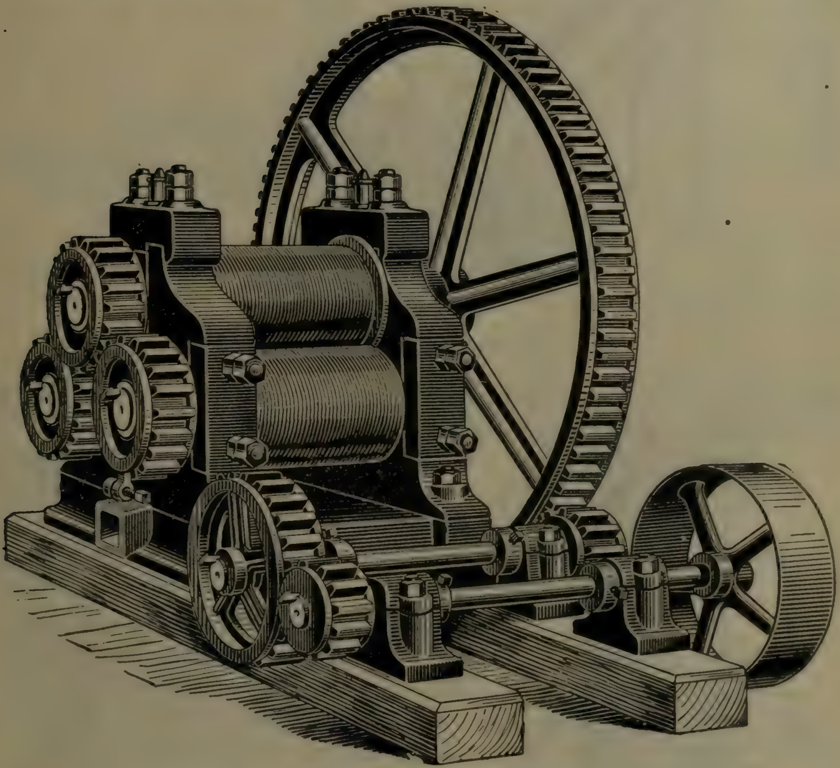


FIG. 7.—Three-roller power mill.

Settling tanks should be equipped with some arrangement for drawing off the clear juice without disturbing the settlings, or for drawing off first the settlings and then the clear juice. Figures 10 and 11 show such devices. Figure 10 shows a swinging barrel which can be used by manufacturers working on a very small scale. Connections suitable for tanks are shown in figure 11. Cut "A" shows an opening near the bottom fitted with a cock. By carefully opening this the turbid liquid is allowed to flow out into a small vessel and is turned into its proper tank when it begins to run clear. Cut "B" is a sliding overflow pipe, which passes through the bottom of the settling tank; by pushing the pipe down, so that its upper end is below the surface of the liquid, the clear juice is drawn from the surface down to the settlings. Cut "C" is an outside swing pipe, which draws the settlings from the bottom of the first tank, then the clear juice follows. When the long arm is turned down, the liquid flows out; when it is turned up, the flow ceases.

---

[1] U. S. Dept. Agr., Farmers' Bulletin 90.

[2] U. S. Dept. Agr., Bureau of Chemistry Bul. 37, p. 85.

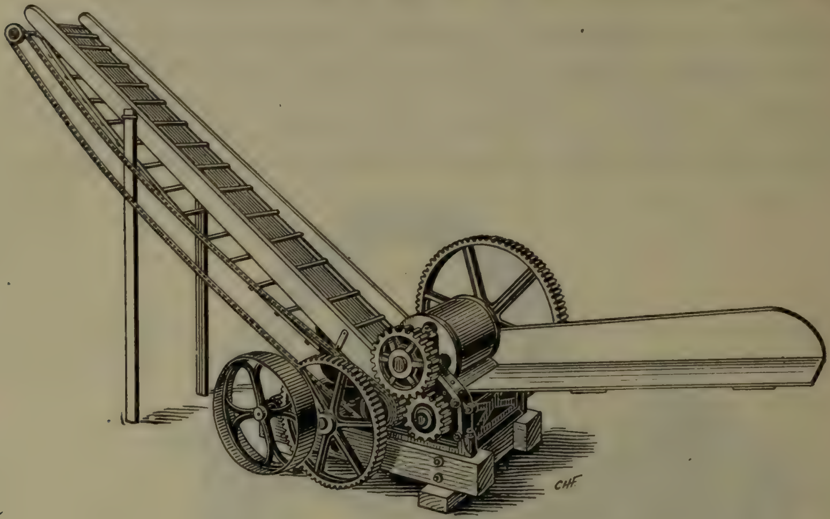


FIG. 8.—Mill with feed table and bagasse carrier.

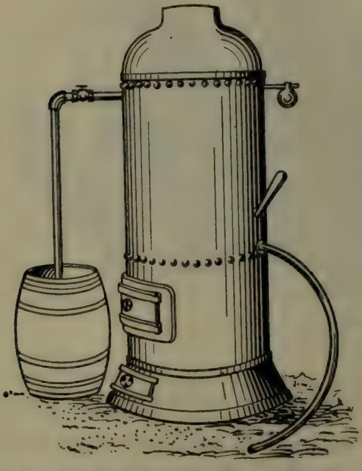


FIG. 9.—Feed cooker for heating juices.

Cut "D" represents possibly the best form for tanks. The swing pipe is placed inside of the tank and by keeping the upper end of the long arm just below the surface of the liquid, the sediment is left behind. A float may be connected with the long arm, keeping it just below the surface of the liquid, and arranged so as not to draw the settlings. The arm when standing erect must be long enough to reach above the surface of the liquid in the settling tank, and the swing pipe should be placed close to the bottom of the tank, far enough from the side to allow the long arm, when turned down entirely, to lie flat upon the bottom, so as to draw all the liquid, as well as the sediment, from the tank; the long arm of the nipple should fit the threads tightly enough to hold the weight of the pipe in any position and not allow it to drop down under any conditions. The settlings or sludge can be used for feeding hogs; but when the settling has been done hastily it should be drawn off to another tank and allowed to settle more slowly, thereby saving more of the juice.

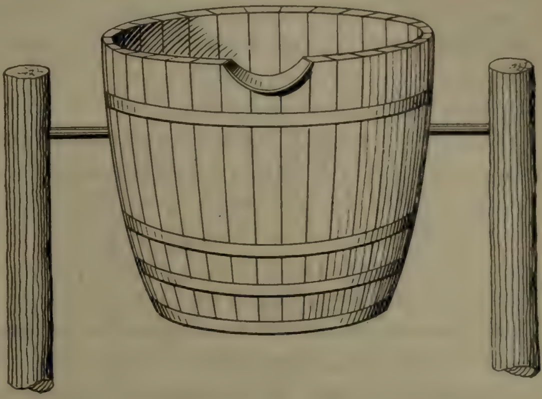


Fig. 10.—A swinging barrel for easily pouring off settled juice.

CLARIFICATION.

The object of clarification is to remove the objectionable substances from the raw juice so that a better grade of sirup may be obtained.

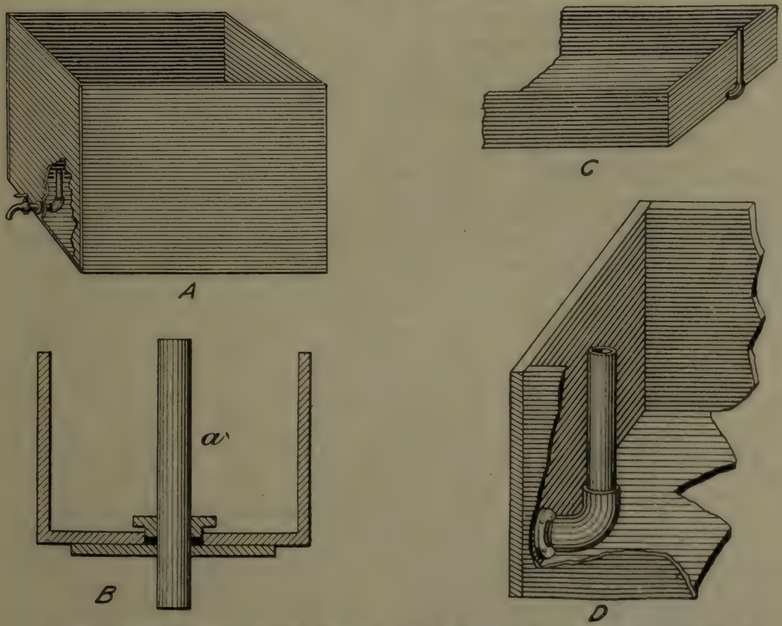


Fig. 11.—Tank connections for drawing off juice. *A*—A settling tank from which the clear liquid is drawn by an upright nipple near the bottom. *B*—A sliding overflow pipe for decanting liquids. *C*—An outside swing pipe for drawing liquid from the bottom. *D*—An inside swing pipe for decanting liquids from near the surface.

The impurities in sorghum juice vary, depending on the season, variety of cane, pressure used in extraction, and the ripeness or condition of the cane. The undissolved impurities are removed to a great extent by settling, but those going into solution must be removed by heat or some chemical treatment. The addition of chemicals, however, while tending to throw certain impurities out, generally leaves in their place part of the foreign substance added and very often completely changes the flavor of the resulting sirup. Many schemes and many substances have been proposed for clarification. Some do the work, while the use of others is questionable.

Heat Alone.

When the raw juice is heated there occurs a coagulation of the albuminous matter which rises to the surface and can be skimmed or brushed off. In coagulating, this material tends to remove some, and generally most, of the suspended matter. Some makers provide special pans or tanks for this heating or clarification; the temperature of the juice is brought nearly to the boiling point and then the heat is turned off and the juice is allowed to stand; the clear layer is then drawn off for evaporation. This process, which is to be preferred especially in the manufacture on a small scale, is also commonly used in cane sirup manufacture.

Heat and Lime.

At certain times of the season, and with certain varieties of cane, the raw juice may be high in acid. To partially neutralize this acidity, lime is added by some makers. This also tends to precipitate some of the organic matter. It is a question, however, whether by its use any more of the organic impurities are removed from the raw juice than by heat alone. The procedure when lime is used is as follows:

Slack completely a quantity of lime with water and then add more water to produce a thin whitewash. Strain the whole through a mesh screen, ⅛ inch or even finer, to remove lumps, unburnt stone, etc. If still too thick, dilute with water. Add only enough of this to almost neutralize the acidity, this point to be determined by testing the juice before and after adding the lime (the whole being stirred thoroughly) by the following method: Dip a piece of blue and a piece of red litmus paper in the solution; if it is acid, the blue litmus paper will turn red and the piece of red litmus paper will remain unchanged, while if the solution is alkaline, the opposite occurs, namely, the blue litmus paper remains unchanged in color while the red litmus paper turns blue. If neither one is affected, the solution is said to be neutral in reaction.

It is far better to lime lightly at first, noticing the color of the juice after the addition of lime, the tint of the blue litmus paper after wetting it in the thoroughly stirred limed juice, and the quality of the sirup produced; then add more or less lime to the next lot of juice, keeping always on the safe side—that is, the acid side. Liming should cease when the juice gives only a faint red to litmus. If it does not change the color at all, too much lime has been used, and fresh unlimed juice should be added.

Litmus paper can be obtained in "books" or in sheets. The former is a little more expensive but is easier to use. If sheet litmus is used, a piece should be cut for immediate use, clipped into small oblong pieces, and put into a small bottle, which may be corked and carried in the pocket. The rest of the sheet should be put away in a corked bottle for future use. Acid vapors in the air and fingers moist with acid juices redden and spoil blue litmus. By moistening the tip of the finger and touching one of the pieces of the blue paper it may be picked up without handling the others. The greatest care must be exercised in using lime for clarification, as an excess will spoil the flavor of the sirup.

Other Methods of Clarification.

Use of phosphoric acid compounds.—In this treatment two methods of procedure have been used. In one the phosphoric acid is added to the raw juice and then limed before heating. In the other, lime is added to alkalinity, then phosphoric acid is added to a slight acidity, and the juice is heated. This procedure greatly changes the flavor of the resulting sirup, and its use is very questionable.

Use of lime carbonate or whiting.—Ordinary slacked lime is strongly caustic while the carbonate of lime or whiting is not, so less care is necessary when using whiting to avoid an excess. The method of using this material is to heat the juice and sprinkle the carbonate over the surface, reheat and sprinkle again, noting the reaction to litmus of the resulting solution. Much more whiting than lime is necessary to neutralize the acidity. Whiting can be added to settling juice to cause a better and quicker separation of the precipitated and suspended material.

Test Glass and Its Use.

As a means of watching the progress of clarification, a test glass may be used to withdraw samples and examine them by transmitted light. Prepare a handle from a ½ to ¾ inch board about 2 feet in length and notch it as shown in figure 12. Obtain a 2 or 4 ounce salt-mouth glass bottle from a drug store and place it in the notch, then by means of a strip of sheet iron bind the bottle in place. This will be found very convenient at various stages of sorghum sirup manufacture.

EVAPORATION OR CONCENTRATION.

The object of the process of evaporation is to remove the water from the raw juice and thereby thicken it to a sirup. This thickening may be carried to a half concentration, filtered, and the concentration completed. This procedure is quite often followed in manufacturing on a large scale, in making a sirup from overripe or underripe cane, or when much lime has been used in clarification.

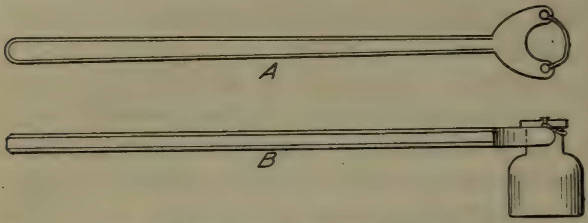


FIG. 12.—Test glass with cut of handle.

Use of Kettles.

The simplest form of boiling apparatus is the old iron kettle. There may be one of these swung from a chain or pole or several may be arranged in a row as a battery, generally called a "Jamaica train," as shown in figure 13. The fresh juice is placed in the kettle next to the chimney and as it heats it is ladled into the next one. The finished sirup is taken from the kettle immediately back of or over the fire box. When a single kettle is used a fire is built around the outside of it, the raw juice is poured in, and the kettle is swung in to the fire. Concentration in this form of apparatus seldom yields light-colored, good-flavored sirup. The greatest care must be used not to allow the flame to get above the level of the juice in the kettle, otherwise it will burn and have a scorched taste. Another precaution necessary when making sirup in this kind of an apparatus is to concentrate a single charge and not to add fresh juice to the boiling sirup. The

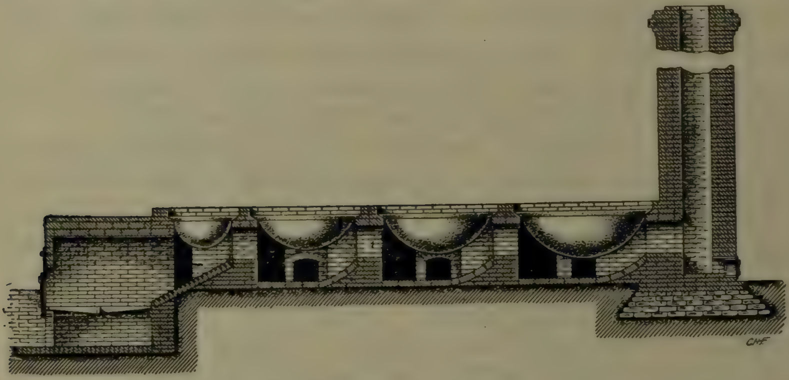


FIG. 13.—Jamaica train of kettles.

latter procedure always gives a dark-colored sirup with a strong burnt flavor. After a charge has been concentrated, the kettle should be swung from the fire and the sediment washed out before it has had time to burn. If the kettle can not be removed from the fire, then after two or three charges, remove the fire and clean the kettle. Any scum collecting on the surface of the boiling liquid should be removed as it forms, which is easily done with a skimmer.

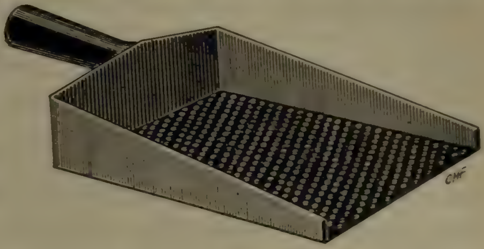


FIG. 14.—A sirup skimmer.

A sirup skimmer is made of metal, and resembles an ordinary dust-pan, with the bottom perforated. It may have a short handle, as shown in figure 14, or a long wooden pole may be attached to it. Another form of skimmer often used is a pole with a narrow piece of metal fastened on to it toward the end. By means of this the scum can be raked to the near edge of the pan and then be lifted off by the regular skimmer.

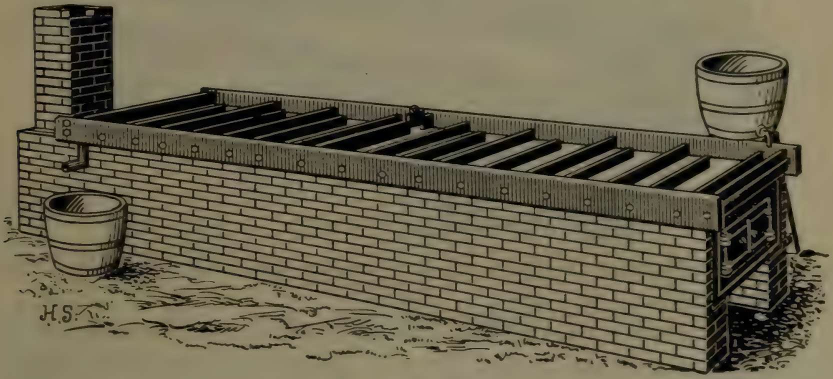


FIG. 15.—A pan evaporator.

Use of Pans and Patent Evaporators.

Instead of kettles many makers use shallow pans (not over 4 to 6 inches deep) made of sheet iron, galvanized iron, or heavy tin. In this case, a single pan covers the whole space occupied by the kettles or there may be two or three pans used, one back of the other. These may or may not be connected so that the juice can flow from one to another. Figure 15 shows a single pan with strips to guide the juice so that it may have a zig-zag course in boiling. The raw clarified juice comes in at the fire end and the finished sirup runs out at the chimney end. In most cases these pans are lifted from the fire for removing the sirup and cleaning at the end of the day.

Many improvements have been made in late years in the evaporation apparatus. Patent evaporators have many points of superiority to recommend them. The bottoms are usually corrugated to give a larger heating surface, the various compartments are connected, and an automatic supply valve is placed so that the depth of the liquid in the evaporator can be regulated. Their construction is such as to produce a quick concentration without the danger of burning or scorching the sirup.

Some makers prefer and use a homemade pan constructed of 1½-inch boards with a sheet-iron bottom carefully luted to the sides. This form of pan can not be recommended under the usual conditions for making a good grade of sirup. After once using the wood becomes soaked with the juice and if allowed to stand empty this juice sours and taints the next boiling. In the long run they are more expensive than iron pans, as the wood soon warps, the joints become loose, and sirup is lost.

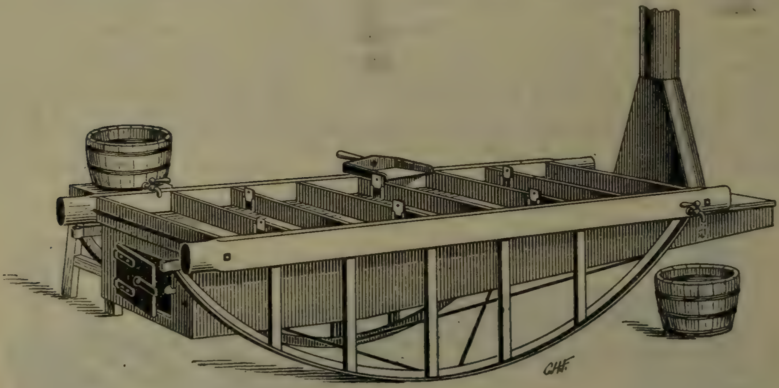


FIG. 16.—A portable evaporator.

Figure 16 shows a portable evaporator which can be easily transported from one place to another and also tilted to allow a flow of juice and sirup. It is used quite extensively in some sections of the country.

To obtain the best grades of sirup when using these forms of evaporators only a thin layer of sirup should be boiled. Not more than a 1½ to 2 inch layer of juice should be in the pans or evaporator at any time, and with care even a thinner layer might be successfully carried. A thin layer makes a quick evaporation and, as a consequence, less color is developed when concentrating to a sirup. Also when boiling a thin layer the impurities reach the surface more easily, and by constant skimming a clear finished product is obtained. Deep boiling in such an apparatus produces the same effect as in iron kettles, namely, a dark, bad-tasting sirup. If an ordinary gutter is placed along each side of the pans when installed the scum can be raked off into this and then caught at the end in a bucket or tub. These skimmings make good food for hogs unless much lime has been added in clarification.

Some makers prefer to boil to a comparatively thin sirup, pass this through a filtering medium to remove the sediment, and then reboil to a proper density. If much lime has been used in clarifying, or if the juice contains much mineral salts, there will be some deposit of salts on concentration. Maple-sirup makers bring much of the floating mineral sediment to the top by adding to the boiling liquid the white of an egg or some whole, fresh, sweet milk, which produces a gelatinous precipitate around the small particles and brings them to the top, where they are removed by skimming. Some sorghum makers do likewise. Under most conditions this material can be removed easily by filtering through flannel or by simply allowing it to settle. Filtering is rather difficult if the sirup is thick and gets cold; a hot liquid filters faster.

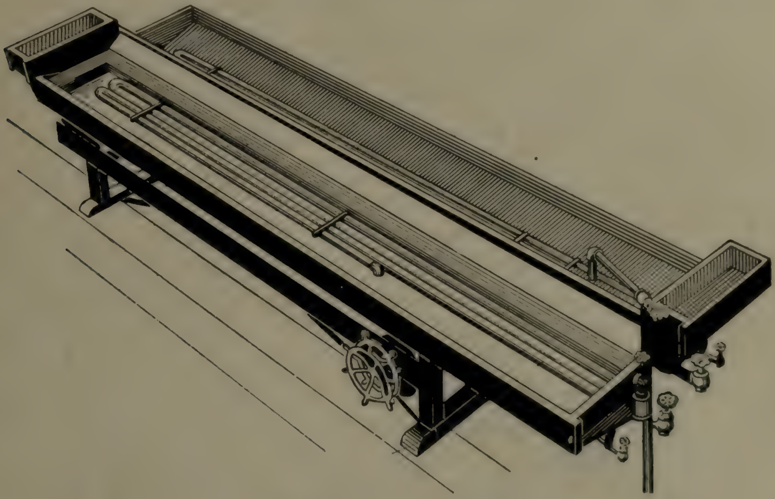


FIG. 17.—A steam evaporator.

In starting a patent evaporator always have water in all the parts and boil this until the raw juice enters. Never heat kettles or pans without water unless it is desired to burn the scale loose. Even this can generally be done in other ways, namely, by boiling water in the pans, either alone or with some acid, as muriatic acid. The acid, however, must be used with the greatest care, as it dissolves the metal of the evaporator. Scraping with an iron removes the scale but it often spoils the evaporator, causing a leak at the place scraped.

Use of Steam Evaporators.

In the steam evaporator the heating is accomplished by means of steam coils. The most common form of such evaporators is a heavy wooden box lined with some metal, as iron, tin, or copper and containing a coil of iron or copper pipe. The coil is removable so that it can be cleaned. Figure 17 shows a form of steam evaporator that is used to some extent; one side is for heating the juice, thereby clarifying it, and the other for the concentration. When working on a large scale, copper tanks with copper coils are used. For the small maker it is a question whether steam evaporation pays or not. When the farmer intends to manufacture sirup for others and make it on a large scale, it might pay to use steam evaporators, but fire evaporators can be purchased that will produce 200 gallons of sirup or more in 10 hours of boiling. The method of operation with steam heating is the same as with the fire evaporators, but there is much less danger of burning and thereby darkening the sirup by the former process. The level of sirup should be not over half an inch to an inch above the coils for quick evaporation and a good-flavored product.

Methods of Determining the Finishing Point.

The finished sirup upon cooling should have a moisture content of not over 30 per cent, equaling a solid content of not less than 70 per cent. One gallon of such a sirup would not weigh less than 11¼ pounds. Commercial practice recognizes this as the minimum density for a sirup. As the sirup comes from the evaporator it is rather difficult to fill and weigh a gallon measure, and again such a weight would be correct only when the whole was cooled down to about 60° F. before the weighing. Some makers determine the finishing point by pouring the sirup from a spoon and watching the last drops fall, but there are two methods which are superior and yet easy to perform. The first is noting the temperature at which the sirup is boiling and the other is to measure the density by means of a Baumé hydrometer.

By thermometer.—As a liquid thickens, the boiling point is raised. Water at ordinary pressure or at sea level boils at 212° F., while a sugar solution with 70 per cent of solids boils at 223.7° F. If, now, a thermometer is placed in the boiling sirup one can roughly judge of the density of the product. In testing a sirup for its density by this manner it would be well to test the accuracy of the thermometer by placing it in boiling water and noting the boiling point. Then finish the sirup at a point 12° to 13° higher than the boiling point of water. Altitude affects the boiling point of liquids. For every 500 feet above sea level, roughly speaking, the boiling point is lowered

1° F., so that water at a point 2,000 feet above sea level would boil at 208° F. and a finished sirup at 220° F. In taking the temperature one must be careful not to allow the bulb of the thermometer to touch the bottom or sides of the evaporator or be exposed above the surface of the liquid, otherwise the reading will not represent the true temperature.

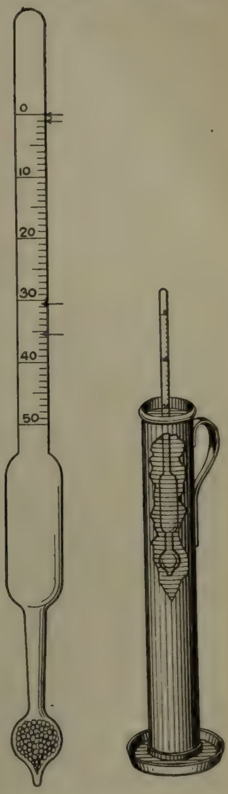


Fig. 18.—Hydrometer and its position in the liquid.

By hydrometer.—A hydrometer or spindle is an instrument for showing the density of a liquid. Hydrometers are graduated to various scales and for various purposes. The one generally used for rough sugar work is the Baumé. The standard of graduation is an arbitrary one and varies somewhat with different makes. The usual Baumé hydrometer shows a graduation of zero to 50 divided into degrees, as shown in figure 18. The instrument being of glass is rather perishable. The density is measured by floating the hydrometer freely in the liquid, which is generally held in a tall cylinder, as shown in the illustration. The point on the scale where the instrument comes to rest is considered the density. With a raw juice this varies from 4° to 8°, while for a finished sirup it should be 38° and over.

The temperature of standardization is 60° F., so for correct readings the sirup under examination should be cooled to that temperature. A boiling sirup that gives a reading of from 35° to 36° when cooled will generally read over 38°. The accuracy of these glass hydrometers is very much affected by using them in hot liquids, hence it is not good practice to use your accurate instrument in the hot sirup. The following table shows the solid content and the water content for different degrees Baumé. These figures are only approximate.

Dry substance and water corresponding to each degree Baumé.

Degrees Baumé.	Dry substance.	Water.	Degrees Baumé.[1]	Dry substance.	Water.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	1.7	98.3	26	46.8	53.2
2	3.5	96.5	27	48.6	51.4
3	5.3	94.7	28	50.5	49.5
4	7.0	93.0	29	52.4	47.6
5	8.8	91.2	30	54.3	45.7
6	10.6	89.4	31	56.2	43.8
7	12.3	87.7	32	58.1	41.9
8	14.1	85.9	33	60.0	40.0
9	16.0	84.0	34	61.9	38.1
10	17.7	82.3	35	63.9	36.1
11	19.5	80.5	36	65.8	34.2
12	21.3	78.7	37	67.8	32.2
13	23.0	77.0	38	69.7	30.3
14	24.8	75.2	39	71.7	28.3
15	26.6	73.4	40	73.7	26.3
16	28.4	71.6	41	75.7	24.3
17	30.3	69.7	42	77.7	22.3
18	32.1	67.9	43	79.7	20.3
19	33.9	66.1	44	81.8	18.2
20	35.7	64.3	45	83.8	16.2
21	37.5	62.5	46	85.9	14.1
22	39.4	60.6	47	88.0	12.0
23	41.2	58.8	48	90.1	9.9
24	43.1	56.9	49	92.2	7.8
25	44.9	55.1	50	94.4	5.6

[1] Taken at 60° F.

It is not to be understood that a degree Baumé corresponds to 1.7 per cent of sugar, for the hydrometer measures other dissolved solids also. When determining the density of the raw juice, a reading should not be made for about twenty minutes or until after the hydrometer has come to rest, when all the air in the juice has escaped.

TREATMENT OF FINISHED SIRUP.

When the sirup has reached the desired density it should be quickly removed from the fire and rapidly cooled. If no care in skimming has been exercised during the concentration, the sirup will have a dirty appearance and even though carefully skimmed, there may be more or less turbidity due to suspended matter. To completely remove this in many cases is a difficult task, but allowing it to remain in the sirup spoils the appearance and to a less degree the flavor. Many methods have been proposed for removing this material. Some makers filter the sirup, some give it an extra treatment, while others allow the sirup to stand to settle the sediment. A filtration of the semisirup during concentration renders a filtration of the finished sirup unnecessary under most conditions. The greater portion of the sediment is thus removed, leaving only the mineral sediment which is thrown down by concentrating to a higher density. Again, upon boiling a thin layer in an evaporator and carefully skimming there is little suspended material left in the sirup.

Sorghum sirup being particularly viscous at high concentrations does not filter easily through flannel or felt, although when worked hot it can be done. A rather coarse, sharp sand makes a good filter bed. The sand should be carefully cleaned, all organic and soluble material and clay being removed. A bed about 6 inches thick makes a filter that will generally remove the sediment. Some makers use 6 to 8 inches of excelsior or wood straw as a filtering medium. The excelsior should be soaked in hot water to remove all soluble matter before using it for this purpose. Sand or asbestos filters, or in fact any filters, should be carefully cleaned after using. All the remaining sugar solution should be washed out and the bed thoroughly sterilized with hot water or steam. When operating on a large scale, sorghum sirup can be forced through filters under pressure and the maximum cleaning in the minimum time obtained.

If the sirup is not too heavy, standing will cause the sediment to collect at the bottom and the clear sirup can be drawn off. For this purpose, tall milk cans with one or two faucets placed 2 and 4 inches from the bottom serve well the purpose. Figure 19 shows such a can with three faucets. The sirup coming from the cooler can be placed in this and allowed to settle. A very heavy sirup, however, or one that is particularly viscous, may stand for as long as a week without any appreciable sedimentation taking place. If the cleansing is carefully done during the process of manufacture the finished sirup will not need much treatment.

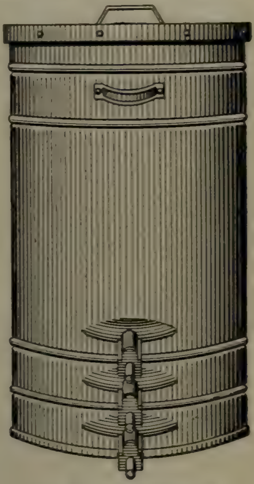


FIG. 19.—A settling can.

Sorghum sirup should be quickly cooled after finishing, so as to hold the color. Many makers run their sirup through a coil of pipe incased in cold water which can afterward be used advantageously for the boiler when a power mill or steam evaporator is used. Some makers have this coil in their raw-juice tank which serves the double purpose of heating the raw juice and cooling the finished sirup. Makers who cool their sirup quickly claim that the color is not darkened and a better grade is therefore produced.

CANNING SIRUP.

The form in which the makers offer their sirup for sale depends greatly upon the market conditions. It may be placed in tin containers with screw tops, holding one gallon, one quart, or half a quart, convenient sizes for local consumption. When packing in this form, the cans should be thoroughly scalded with hot water before filling. Wooden pails holding five gallons, or half and full barrels, can be used. When using wooden packages, they should be carefully washed out, and for the best after effects should receive a thorough steaming before filling. Fermentation can be long prevented by careful handling of the sirup. If the sirup goes directly from the evaporator into previously steamed barrels there should be no trouble from fermentation, nor should there be much danger of it when the sirup is carefully covered, cooled, and then canned in sterilized packages.

Sorghum sirup can be graded as to color and also flavor by establishing standards on these points and classifying the output. This is of extreme importance in supplying a local market, and it might be of value to the makers of sorghum sirup in a certain locality to unite and sell their product under such conditions. The usual purchaser of such a commodity desires two purchases of the same material to have the same color and flavor. They are not informed as to why manufacturing conditions affect these and why all sorghum sirup is not of the same appearance and taste. By having such an association of farmers and a system of standardization, different products can be classified. As maple-sirup makers have found this plan of value, it might be profitably applied to the sorghum-sirup industry.

PREVENTION OF CRYSTALLIZATION.

Crystallization results from making a supersaturated solution of a substance in a liquid. In the case of sirups the sucrose becomes concentrated to a point at which it is no longer soluble in the water present, and hence it crystallizes out. This is the fundamental principle of recovering or manufacturing sugar. In these processes every care is taken to prevent the destruction of sucrose during manufacture so that a greater yield of sugar will be obtained. If sirup is the product to be made, on concentration it would be natural for a crystallization to take place, and to prevent this crystallization as far as possible the following precautions are taken:

Sucrose, on being heated in the presence of an acid or on long and high heating in water, becomes broken down into two sugars. One of these is crystalline in form; the other is liquid under most conditions. These two sugars are known as invert sugar and possess a sweet taste. The modification of the process referred to is to leave the juice after clarification more acid than in ordinary work. In other words, to use less lime or none at all for clarification. On concentrating such a juice a natural inversion of the sucrose will take place, and hence there will be less crystallization. This may and does suffice in most cases, but when the sorghum is very ripe (has a high sucrose content) the sirup may still crystallize. Some makers accomplish the desired inversion by allowing the cane to remain in the field for 24 hours or more after cutting. This practice will certainly reduce the amount of sucrose in the cane, but its effect on the flavor of the resulting sirup is a matter of conjecture. However, it is done extensively in sorghum sirup manufacture. Sorghum juice, as expressed from the cane, contains some little starch and gummy materials. If these are not removed in the process of settling and clarification, they will tend to keep a sirup from crystallization, especially if the starch becomes soluble by boiling. It is not the usual policy, however, to allow them to remain in the juice for this purpose (though they are sometimes present, due to poor settling and skimming), as they do influence the flavor of the sirup. The danger of crystallization in sorghum sirup is much less than in cane or maple sirup. Long standing, however, in a cool place may cause crystals of sugar to form.

COMMENTS BY REPRESENTATIVE SIRUP MAKERS.

Mr. Seth H. Kenney, of Minnesota, a sorghum maker of 50 years' experience, states:

> I grow Minnesota Early Amber cane and make 10,000 to 15,000 gallons of sirup yearly. I also buy 1,000 to 1,200 tons yearly, at $2 per ton. The average cost of growing cane and hauling it half a mile to the mill is 10 cents per gallon of sirup manufactured. The average cost of making the sirup is 9 cents a gallon. Two pounds of seed are required for an acre. The planting should be done so that the cane will not all ripen at once. The plants should be thinned. It is important to cultivate cane well when small. When the seed heads begin to turn brown, I begin to grind. I cut cane 24 to 48 hours ahead of my wants. If there is an appearance of frost, I cut all standing cane and pile 6 hills in a pile. With cane cut 12 to 24 hours before a frost the juice cells shrink enough so that frost does not injure it. I know nothing better than lime for defecation and the steam pan for evaporation. The lime is about as thick as whitewash when used. About 1 quart of this milk of lime is used in each 100 gallons of raw juice. It is allowed to drip in the spout that contains the juice as it comes from the mill. A good sirup can be made without lime—and probably nineteen-twentieths is manufactured in this way—but the use of a quart of milk of lime in 100 gallons of juice is preferable. The use of lime at the right time, in the right place, and in the right quantity requires skill. It is necessary to bring the juice nearly to a boil, skim, draw off into the evaporator, boil rapidly, and cool the sirup quickly. The latter should weigh 11½ to 12 pounds per gallon. The pan should be well cleaned once a day. The tanks, etc., should be clean and sweet.

Mr. Conrad Munz, of Illinois, who has made sirup since 1889, writes as follows:

> I have made as high as 29,000 gallons of sirup a season. My first attempts were with a small mill and fire evaporator, but am now using a mill crushing 5 tons of cane per hour and corresponding steam defecation and evaporation. I have discontinued the use of clarifiers, as lime and sulphur, and now use nothing but heat, and plenty of it, to make our sorghum sirup.

Densmore Bros., of Minnesota, say:

> The best soil in which to grow sorghum is a light loam inclined to be sandy rather than rich in vegetable plant food. The best results follow the use of wood ashes as a

fertilizer. Soil fertilized with barnyard manure or ground which has been used as a hog yard or pasture is to be avoided for sorghum, as it is a voracious and indiscriminate feeder from the soil. The yield of cane, seed, or sirup is a true index of the care bestowed in selection of the soil and cultivation. The ground must be kept free from grass and weeds, so the air can have free access between the rows and to all parts of the cane. The yield of sorghum cane is from 9 to 12 tons to the acre and of sorghum seed 10 to 20 bushels per acre. In a record of a hundred or more lots of cane, the lowest yield of sirup was 60 gallons per acre, and the highest 245 gallons, the average being 150 gallons. In manufacturing sirup from sorghum juice, it must be remembered that raw sorghum juice is a very unstable liquid—it soon begins to ferment and decay. To forestall this condition milk of lime and heat are necessary. Good defecation is important; evaporation affords no remedy for poor defecation. As it comes from the mill the juice is full of impurities, which, if allowed to remain in the sirup, affect its quality. Many substances have been tried in the defecation but the invariable conclusion is a return to lime. It neutralizes the acids and cuts the gummy matter. It is a necessity to remove impurities from the juice before evaporation begins. The juice after the lime is added is agitated by pumping and then heated to about 180° F. and finally to about 212° F., then the heat should be shut off and the impurities allowed to separate as scum and sediment. Three defecators should be used; one being filled, one settling, one being drawn from. An automatic swing pipe drains the juice from near the surface to the evaporator, where there is a valve for regulating the supply. When not in use the swing pipes are turned up to full height, so as not to act. The outlets from the defecators all connect with a pipe which conveys juice to the evaporator, where it is concentrated as quickly as possible. Boiling should be accomplished in as thin a film of juice as possible. The thicker the layer, the longer the time and the darker and stronger the sirup. The temperature for finishing an 11½-pound sirup at the altitude of St. Paul is about 225° F.

J. J. Bishop, of Indiana, writes:

I strip all of my cane before cutting and let it stand a few days, then top and cut. Trials of grinding cane without stripping produced a bad sirup as there was more filth and sediment than with stripped cane. The juice is allowed to settle in cement tanks and then siphoned two or three times. Boiling is accomplished in the ordinary form of patent evaporator, which in the winter is used for maple sirup.

J. T. Elliott, of North Carolina, writes:

I prefer Gooseneck to the other varieties used around here. When the cane is ripe, I go into the field, strip fodder, and scatter it on the land; then cut the heads and place in piles; then cut cane and haul to mill as soon as possible; if crowded it may be one or two days before it is ground. I always try to cut all cane before the frost; a light frost will not do much damage, but a heavy frost or freeze will ruin the cane for sirup making, and under such circumstances I cut and give it to the hogs. The cane is ground in a 3-roller mill and the juice strained through coarse cloth or sacking. All juice is worked up the day the cane is ground; allowing it to stand over night causes it to sour and become unfit for sirup making. My evaporator is a homemade one, 20 by 60 inches. I took dressed hardwood, 2 by 10 or 12 inches for sides, and bolted together at the ends; then nailed heavy sheet iron on for a bottom. The whole is placed on brick walls 15 inches high so as to admit of wood and fire under it. The evaporation is carried on as quickly as possible. The juice is brought to a boil and then allowed to concentrate, skimming off foam as soon as it begins to form, with perforated ladles and continuing to skim until nearly done, which is told by the way it drops on cooling. When finished the pan is removed from the fire by a man at each corner, cooled and measured. If a small crane is fixed on ceiling of shed, one man can remove the pan. The skimmings are good for hogs. Farmers in this section say the heads on a row of cane are worth as much to feed hogs as a row of corn of the same distance.

W. J. Maxwell, of Missouri, makes the following statement:

Hand harvesting of cane is the only satisfactory method we have found for a high grade sirup, as a harvester will cut all, and some canes are unfit for sirup of high quality. Stripping or removing the blades seems quite a task, but carefully testing quantity and quality we find ourselves from $5 to $7 per acre ahead by doing so and besides have a lot of good feed. The sooner the sirup is made after the cane is cut the better the grade, though a few days to a week does not materially damage the quality; if cut during dry weather, the quantity of sirup is decreased. In case of a heavy frost or freeze we cut and shock the cane. For manufacture of a good sirup one needs a heavy mill with greater capacity than the evaporator used. The juice as it comes from the mill is run through a strainer made of fine wire (same as used for milk strainer) into one of two tanks with valve between, about ½ inch from the bottom of the one that the juice runs into. This pipe with valve empties juice into the second one and from this one the juice goes to the evaporators. I always have these tanks full of juice or about so at least. The sediment settles in tank 1 and whenever the juice gets low enough the sediment is turned to the hogs, as it is a great deal better to get it out of the evaporators. I used to think clarifiers were necessary (such as lime and alum), but I have found out differently and my sirup now is better without their use. I use an evaporator with a good furnace under it, something that will start juice to boiling two minutes after lighting the fire. By allowing the raw juice to enter one end and taking the finished sirup off at the other, we have a continuous process. For juices rich in sugar and good in color, we have the layer of juice in the evaporator about 1 inch deep, but with poor juice we keep the level as low as possible to finish into sirup in 20 minutes. As the raw, cold juice enters the evaporators the sediment and impurities collect at this point and are skimmed off. My experience is that all changes in flavor and color of sirup take place while it is hot and this is why we shorten the time of evaporation and why we run our finished sirup from the evaporator immediately into a cooling tank.

Bieder Bros., of Minnesota, who have manufactured sorghum sirup for 16 years, write as follows:

We have recently put in an all-steam plant. Have a 5,000-pound mill, which furnishes bagasse dry enough to burn immediately. We use this under our boilers together with cord wood, and find a saving of about 35 per cent in fuel, besides saving the expense of hauling. The grates are hollow and air is forced through by means of a blower to make a more intense fire. The juice coming from mill is strained and pumped to one of three defecating tanks, where lime of 13° B. is added (1½ quarts to 100 gallons). The quantity of lime depends on the richness and greenness of the juice. Steam is slowly turned on in this tank and the temperature brought up to 210° F. If the right amount of lime is added the scum will come to the surface and the juice be clear. Three-fourths to one hour is necessary for settling, and then the clear juice is run off to the evaporator. A shallow boiling is practiced—not over one-half inch of juice above the steam coils at any time. When finished the sirup is allowed to run over pipes of cold water to quickly cool it.

ECONOMIC CONSIDERATIONS.

LOCATION AND ARRANGEMENT OF A SIRUP PLANT.

The small maker should consider carefully the location and arrangement before putting up a plant, as these points are most essential to economy in manufacture. It is impossible to enter into a very thorough discussion of this subject or to lay down hard and fast rules, as many circumstances might affect one's decision. It is certain that the boiling house, etc., should be located so that it is easily accessible for bringing in the cane and fuel and storing and taking care of the finished product. In a small plant it is not necessary to cover all the equipment. The mill should be placed on the highest level, the raw juice caught at a lower point, and the evaporator be placed lower. In this way gravity is made to play an important part. This same idea can be carried out with power mills. In manufacturing on a larger scale the mill is best placed on the ground, the raw juice is pumped into storage tanks placed higher up, and from there it runs down through the clarifiers to the evaporators on the ground floor.

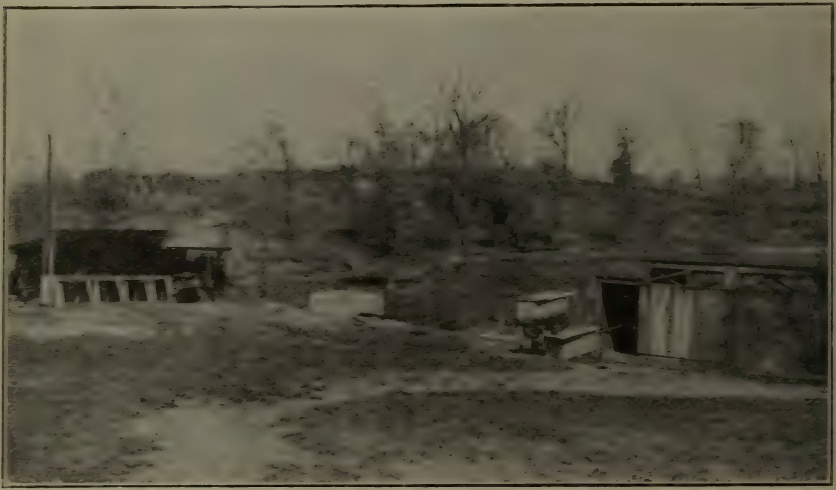


FIG. 20.—General view of sorghum sirup plant. At the extreme left are the cane mill and engine; in the center, the cement settling tanks; and at the right the oil tank and boiling sheds.

The boiling house under all conditions should be covered and provided with a good ventilator in the top so as to dissipate the steam. A good form for such a structure is shown in figure 22, one of the sides of the house being raised up to form an awning which when let down still allows for a passageway around the evaporator. If possible the floor of the boiling house should be paved, as with brick, wood, or cement, and sloped to furnish drainage. If a fire evaporator is used it would be well to have a partition at the fire door so that when stirring the fire or adding new fuel no ashes would get into the sirup. In a word, the arrangement should be such that the evaporation can be carried on with dispatch and under cleanly conditions. Many makers use their maple camps for making sorghum sirup also. The same camp and arrangements will serve admirably for the two, providing the location is convenient.

A power mill should be covered; in fact, it could well be placed in a house similar to the boiling sheds shown in figure 22, with sides capable of being raised. The evaporation house might be made large enough to hold the engine as well as the mill.

FUEL.

The fuel for the evaporation and other processes is a very important item. That one should be selected which is the cheapest for the work to be done; whether it be wood, coal, or oil. Quite a number of makers use a crude-oil burner under their evaporators; this, in connection with a jet of steam, gives a good fire for evaporation and one capable of adjustment. Many trials have been made in using the crushed cane (bagasse) as it comes from the mills as a fuel, but a special fire box is necessary for this purpose (fig. 23).

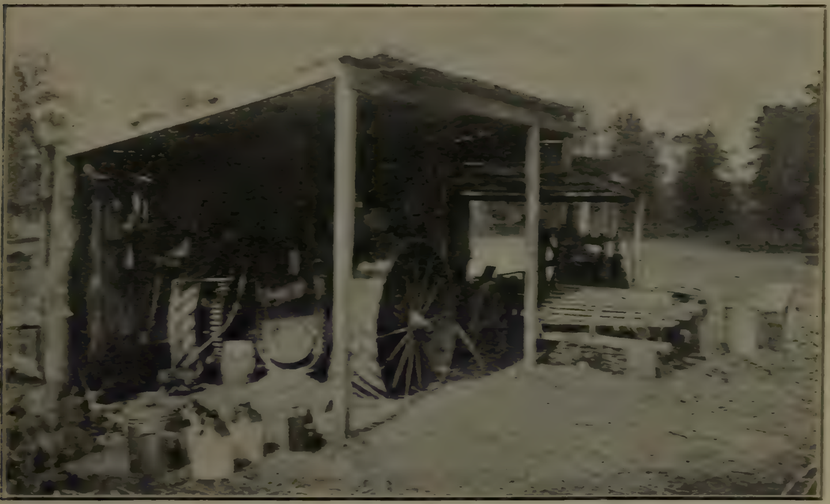


FIG. 21.—Traction engine and cane mill.

The greatest trouble with bagasse is its high moisture content, as the usual mill does not press the cane dry, but by spreading the crushed cane out in the sun a good fuel can be obtained. In the sugar-cane industry of Cuba the bagasse furnishes in many cases from 90 to 100 per cent of the fuel for operating the whole plant; in Louisiana it furnishes from 50 to 80 per cent of the fuel. The bagasse in these two places is drier than that obtained by sorghum makers unless double mills are used. Again, these large cane plants are equipped with special furnaces for handling the bagasse.

Figure 23 shows an arrangement for burning bagasse on a small scale under pans or evaporators. It consists of a sheet-iron funnel tapering toward the end nearest the furnace, so as to compress this light fuel slightly as it is pushed through into the furnace, and having a sheet-iron door hinged to the upper surface. This is a safer and better method of firing than to put the crushed canes directly upon the fire. A fork full of the fuel pushes the door inward, and the door closes itself when the fork is withdrawn.

Another form consists of a small oil burner in the furnace, the bagasse being fed to the fire by hand. There may be some danger, however, in this kind of firing.

MAKING SIRUP ON SHARES.

It quite often occurs that a farmer may grow sorghum but does not care to manufacture it into sirup. Upon what basis should the sirup be made? A central factory seldom raises all its own cane—it buys from the farmers. In this case the agreement is generally drawn up for the cut cane, free of trash, and either stripped or not stripped of leaves at a given price per ton of raw material. On a small scale this is seldom done, one of two general methods being followed in such cases. Either the maker produces the product at a stated price per gallon for the farmer or on shares, that is, giving the farmer a certain number of gallons of sirup (5 to 15) for each ton of cane. In either case it is necessary to keep the cane separate and the juice also, even up to the boiling if the farmer is to receive his share of sirup.

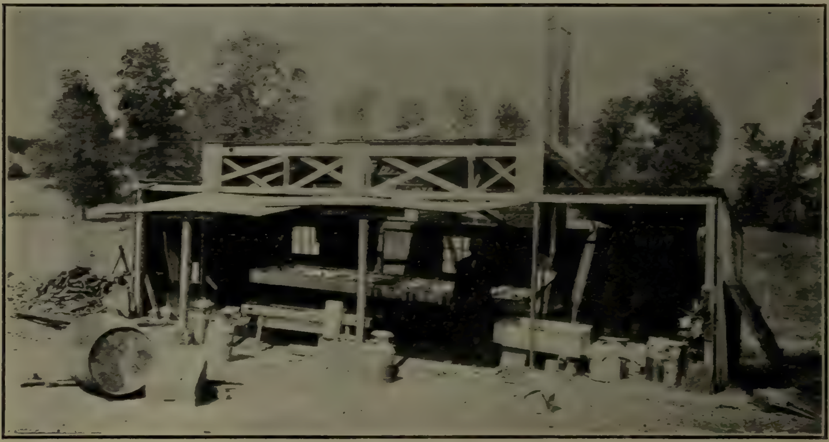


Fig. 22.—Evaporation house.

There is, however, a way of approximately determining the amount of sirup that will be made from the cane. By using this method it is not necessary to boil each lot separately, but only to grind the cane separately and then collect the raw juice in tanks where it can be measured. From the gallons of raw juice and its Baumé reading the gallons of sirup that will be made can be calculated.

The settling tanks are convenient for measuring the raw juice. If the tank is oblong or square, take the inside dimensions, length and width, in inches, multiply these together and divide the result by 231 cubic inches to obtain the gallons of juice in the tank for each 1 inch of depth. By inserting a stick or rule in the tank the number of inches of juice is obtained and this figure multiplied by the gallons per 1 inch of depth gives the number of gallons of raw juice. If the measuring tank is round, to obtain the gallons of juice for 1 inch multiply the diameter expressed in inches by itself (in other words, square the diameter) and then multiply this figure by 0.7854; divide the result by 231 cubic inches and the result is the gallons of juice contained in 1 inch of height.

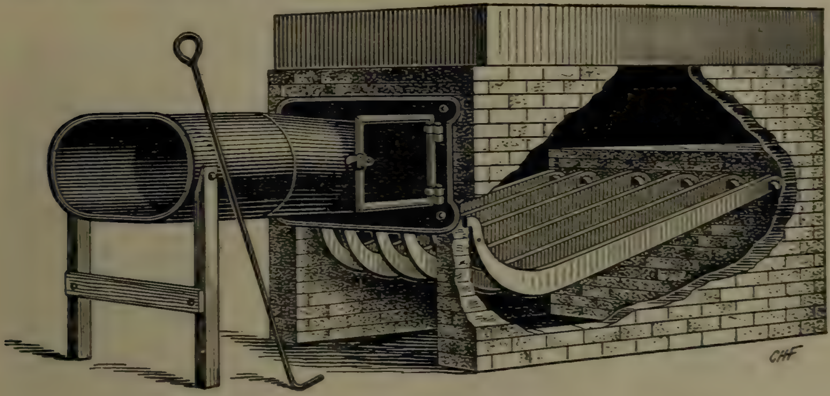


FIG. 23.—A bagasse burner.

The other figure necessary for the calculation is the density of the juice as determined by means of the Baumé hydrometer. This instrument can be placed in the tank, provided the juice is deep enough to allow it to float freely. From these two figures the yield can be obtained. One maker, Mr. A. P. Cleland,[1] has found that 10 gallons of juice with a reading of 6° Baumé make 1 gallon of finished sirup; from this he calculated the following sliding scale:

Juice, degrees Baumé.	Gallons of juice per gallon of sirup.
6	10
6½	9
7	8½
7½	8
8	7½
8½	7
9	6½
10	6
11	5½
12	5

---

[1] U. S. Dept. Agr., Farmers' Bulletin 135, p. 39.

It is noted that the gallons of juice multiplied by the Baumé reading gives approximately 60 in each case. Each maker can and should prepare for himself such a table as his method of manufacture may not be at all like the one cited. To do this it is necessary to measure several tanks of juice and obtain their Baumé reading, then concentrate the juice to a sirup in the usual way and measure the finished sirup. By multiplying the Baumé reading of the juice by the number of gallons of raw juice and dividing by the number of gallons of finished sirup made, the figure on which to base the table (60 in the case just cited) will be found. With this beginning a table can be prepared for different Baumé readings on the raw juice. In this way as soon as a separate lot of cane is ground the juice can be measured, the density determined, and the number of gallons of sirup due the cane grower can be learned without interfering with the work of the evaporator.

BY-PRODUCTS AND THEIR USES.

Bagasse.—The crushed cane as it comes from the mill is known as bagasse. The use of this material as a fuel has been discussed on page 35. It has also a value as a fertilizer. By returning it to the field and turning it under most of the fertilizing ingredients taken from the soil by the plant are restored. Bagasse can also be used as a roughage for feed, but it has not the food value of the unpressed stalks. Its principal use seems to be as a fuel. Attempts have been made to manufacture paper from bagasse, but without much success.

Leaves and blades.—In stripping the cane from 5 to 15 per cent of the weight of the crop is removed; in other words, the leaves when green weigh on an average about 10 per cent of the topped cane. If they are frostbitten, or dry, or both, they may not be over 4 per cent of the weight of the cane. Some makers on buying cane consider a long ton of unstripped cane equal to a ton of stripped cane—that is, 2,240 pounds are equivalent to 2,000 pounds, which would make the leaves and dirt amount to about 12 per cent. Some varieties bear more leaves than others, so only average figures can be given. The leaves make a good cattle food, or by allowing them to remain in the fields and then burning them with the stubble they furnish a good fertilizer.

Seed heads.—The amount of seed per acre varies with the variety of sorghum and the stand. Estimates ranging from 5 to 30 bushels to the acre are given, an average figure for the usual varieties of sugar sorghum being about 10 bushels. They have a large feeding value, claimed by some to be equal to corn, but most authorities give them a place much below corn. On account of the shape and hardness of the seed, better feeding results are obtained by first boiling or grinding them. Because of the difficulty of removing the hulls and the astringency of the seed coating, the grain is less relished by animals than is that of the nonsaccharine varieties.

ANALYSES OF SORGHUM VARIETIES.

In the following table are given the results of analyses of cane grown in various locations during the year 1910. The data include the Baumé reading and the percentages of sucrose and invert sugar in the expressed juice. It is doubtful whether the average run of sorghum cane of these varieties gives such high figures, but they serve to show what can be expected if the growing season is a good one and the planter uses care with his crop. The samples of Collier and Colman cane show very high percentages of sucrose with rather low invert sugar content.

Analyses of sorghum, made in 1910, arranged according to varieties.

[Results are analyses of expressed juice.]

Variety and locality.	Degrees Baumé.	Sucrose.	Invert sugar.	Total sugar.
		Per cent.	*Per cent.*	*Per cent.*
Sumac:				
Biloxi, Miss	8.1	4.07	7.37	11.44
Do	10.1	10.93	3.21	14.14
Dalhart, Tex	10.6	11.34	3.49	14.83
Do	8.6	2.88	10.90	13.78
Brownsville, Tex	9.0	8.52	4.74	13.26
Do	8.0	4.26	6.70	10.96
Planters:				
Biloxi, Miss	9.7	10.59	1.91	12.40
Arlington, Va	9.7	2.98	10.70	13.68
Do	11.3	4.15	11.69	15.85
Compton, Cal	9.7	9.27	3.28	12.55
Monette, S. C	11.6	14.47	2.84	17.31
Do	12.2	15.38	1.74	17.12
Brownsville, Tex	7.3	5.58	3.86	9.44
Do	7.9	8.22	2.05	10.27
Dalhart, Tex	8.4	4.15	5.78	9.93
Do	8.6	3.17	6.54	9.71
Red amber:				
Biloxi, Miss	9.3	9.57	2.72	12.29
Arlington, Va	9.2	0.75	12.57	13.32
Do	10.0	3.02	11.65	14.67
Monette, S. C	10.4	6.41	8.70	15.11
Compton, Cal	11.9	1.43	14.46	15.89
Dalhart, Tex	6.3	1.88	6.32	8.20
Brownsville, Tex	8.3	4.64	6.87	11.51
Do	7.4	1.81	7.64	9.45
Minnesota amber:				
Biloxi, Miss	10.7	12.89	1.72	14.61
Arlington, Va	10.0	3.54	11.15	14.69
Do	10.5	4.26	11.40	15.66
Compton, Cal	7.5	5.77	2.95	7.72
Monette, S. C	10.7	13.00	2.03	15.03
Dalhart, Tex	7.4	4.98	4.54	9.52
Do	8.5	4.82	6.78	11.60
Brownsville, Tex	7.2	5.01	4.18	9.19
Do	8.0	4.37	6.98	11.35
Orange:				
Biloxi, Miss	10.3	12.32	1.88	14.20
Arlington, Va	8.1	2.86	7.35	10.21
Do	10.5	1.66	14.62	16.28
Compton, Cal	9.2	7.99	3.38	11.37
Monette, S. C	....	14.30	1.75	16.05
Do	12.7	15.53	2.14	17.67
Dalhart, Tex	6.2	1.70	5.72	7.42
Brownsville, Tex	6.8	2.64	5.91	8.55
Do	9.6	8.14	5.35	13.49
Honey:				
Biloxi, Miss	8.6	8.22	4.44	12.66
Arlington, Va	11.0	3.58	13.57	17.15
Do	11.2	11.46	4.48	15.94
Compton, Cal	11.6	12.59	1.50	14.09
Dalhart, Tex	9.7	1.73	11.97	13.70
Brownsville, Tex	8.3	5.66	5.78	11.44
Do	8.7	8.44	3.42	11.86
Gooseneck:				
Biloxi, Miss	8.9	8.67	4.42	13.09
Arlington, Va	8.7	3.84	8.80	12.64
Compton, Cal	8.5	7.39	2.91	10.30
Dalhart, Tex	10.5	10.48	4.63	15.11

Analyses of sorghum, made in 1910, arranged according to varieties—Continued.

Variety and locality.	Degrees Baumé.	Sucrose.	Invert sugar.	Total sugar.
		Per cent.	*Per cent.*	*Per cent.*
Colman:				
Compton, Cal	11.9	13.79	1.12	14.91
Monette, S. C	....	15.30	1.28	16.58
Do	11.2	14.25	1.93	16.18
Collier:				
Compton, Cal	10.9	12.14	2.12	14.26
Monette, S. C	13.7	18.39	0.61	19.00
Do	14.0	18.24	0.92	19.16

STATISTICS.

The United States Census reports from 1860 to 1890 show the gallons of sorghum sirup made during the year previous to the census year. These figures are only approximately accurate, as it is quite impossible to obtain exact data because so much sorghum is made on a very small scale; were this included, the totals would be much larger. It is noted in the table that in the year 1879 more sorghum sirup was produced than in any other before or since, namely, nearly 28,500,000 gallons, while in 1899 nearly 17,000,000 gallons were produced.

The production in some States has decreased rapidly since 1880, as for instance, Iowa, Illinois, Kentucky, and Missouri, while in other States it seems to remain about the same, namely, Tennessee, Arkansas, Alabama, and Virginia. In only a few are increases shown, notably North Carolina.

Sorghum sirup produced (United States Census reports).

States.	Year of census report.				
	1900	1890	1880	1870	1860
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1. Tennessee	2,047,655	2,542,533	3,776,212	1,254,701	706,663
2. Missouri	1,990,987	2,721,240	4,129,595	1,730,171	796,111
3. North Carolina	1,419,570	1,268,946	964,662	621,855	263,475
4. Kentucky	1,277,206	2,094,962	2,962,965	1,740,453	356,705
5. Arkansas	1,223,691	1,868,952	1,118,364	147,203	115,604
6. Alabama	1,168,868	1,242,689	1,163,451	267,269	55,653
7. Mississippi	1,162,269	972,216	1,062,140	67,509	1,427
8. Texas	877,232	1,749,910	432,059	174,509	112,412
9. Georgia	767,024	1,342,803	981,152	374,027	103,490
10. Kansas	735,787	1,484,937	1,429,476	449,409	87,656
11. Illinois	625,939	1,110,183	2,265,993	1,960,473	806,589
12. Indiana	579,061	751,808	1,741,853	2,026,212	881,049
13. Virginia	555,321	546,328	564,558	329,155	221,270
14. Iowa	521,212	1,386,605	2,064,020	1,218,636	1,211,512
15. South Carolina	478,190	559,216	281,242	183,585	51,041
16. West Virginia	450,777	512,747	817,168	780,827	....
17. Ohio	341,523	547,630	1,229,852	2,023,427	779,076
18. Wisconsin	160,414	219,070	314,150	74,478	19,854
19. Minnesota	157,605	340,792	543,369	38,735	14,178
20. Indian Territory	97,381	....	....	....	....
21. Nebraska	92,413	634,146	246,047	77,598	23,497
22. Oklahoma	81,891	31,299	....	....	....
23. Louisiana	48,727	107,763	33,770	180	....
24. Utah	28,017	24,293	58,221	67,446	25,475
25. Michigan	24,059	45,524	102,500	94,686	86,953
26. South Dakota	9,859	29,372	....	....	....
27. Arizona	9,031	4,808	5,771	....	....
28. Delaware	8,952	3,371	25,136	....	....
29. California	8,671	1,670	2,459	333	552
30. Pennsylvania	6,514	33,708	69,767	213,373	22,749
31. Maryland	4,058	4,732	19,837	28,563	907
32. New Mexico	2,812	3,510	251	1,765	1,950
33. Colorado	2,661	19,964	3,227	....	....
34. Oregon	2,473	2,706	2,283	....	....
35. Nevada	1,465	930	350	3,651	....
Total	16,972,783	24,235,219	28,444,202	16,050,089	6,749,123

Issued December 21, 1911.

142

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 478.

HOW TO PREVENT TYPHOID FEVER.

BY

LOGAN WALLER PAGE, JOHN R. MOHLER, AND
ERWIN F. SMITH.

1862 1862

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

C

INTRODUCTION.

Current medical literature contains many references to highly satisfactory results obtained by the use of antityphoid vaccine in the reduction of typhoid mortality. The value of antityphoid vaccination has been investigated by specially appointed commissions in England, Germany, France, and the United States, and in every case their conclusions have favored the adoption of this prophylactic measure.

The prevalence of typhoid fever in practically every section of the United States makes any measure which will protect the individual or assist in preventing the spread of the infection extremely important to the community. The production of artificial immunity against this disease by antityphoid vaccination constitutes such a measure, and it is destined to render real service, especially to those about to enter conditions in which they will be unduly exposed to the disease.

The safety and certainty of vaccination as a method of protection against the disease have been conclusively demonstrated during the last 10 years on a large scale by the experiments of the Japanese Army, the English Army, and more recently the United States Army.

The method of applying this prophylactic is very simple. The initial discomfort is not more than that caused by an ordinary hypodermic injection, and the subsequent brief reaction is usually less than in a case of vaccination against smallpox. Inoculation is deemed unnecessary for old people, for very young persons, and in general for civilians who live at home; and it is inadvisable for people in ill health. But for well persons exposed to the dangers of field service it is urgently advised that the regulation three inoculations of the United States Army be taken.

These inoculations are made at intervals of 10 days, the entire course thus requiring 20 days. The injection is always made under the skin—not into the skin or muscle—and the site usually selected is the arm.

It is a well-known fact that a great many cases of typhoid fever occur among the men engaged in the field work of this department, causing inconvenience and loss to the service as well as to the individual. In one bureau during the last 10 years there have been 28 cases and 5 deaths from this malady. Messrs. Page, Mohler, and Smith were therefore appointed a committee, representing the bureau chiefs, to draw up a plain statement of the nature of typhoid fever and the means of preventing it. The statement they have prepared was originally intended for the benefit of members of the Department of Agriculture only. In view of the widespread ravages of this disease, however, I am impelled to make the statement available to the general public also.

Those members of the department who desire the treatment should make application to the chiefs of their respective bureaus, who will in turn refer such applications to the Surgeon General's Office. The Surgeon General's Office will send the prophylactic in the necessary quantity, with instructions, so that any competent physician can properly apply it.

Physicians desiring to use the vaccine in general practice may obtain it in the same manner in which they now obtain diphtheria antitoxin or vaccine for the prevention of smallpox, inasmuch as a number of biological firms well known to physicians and druggists are now licensed under the Federal law to engage in the preparation and distribution of antityphoid vaccine.

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *November 7, 1911.*

HOW TO PREVENT TYPHOID FEVER.

THE DANGER FROM TYPHOID.

Typhoid fever is a communicable disease, more to be dreaded on the whole than smallpox, because at present in countries which practice vaccination smallpox is a disease which occurs only occasionally and is soon stamped out, whereas typhoid fever prevails widely in all civilized countries, attacking by preference the young and middle aged, and causes not only many deaths every year, but great economic losses. Serious impairment of the heart and other organs may persist after recovery. In recent years the subject has been brought home to this department by numerous cases among its members, and it has been thought desirable to put on record a plain and trustworthy account of the way in which the disease is usually contracted and what methods may be employed for its prevention.

The disease is not contagious in the ordinary sense of the word, i. e., it is not usually spread from person to person by touch, as in the case of scarlet fever or smallpox. Careful nurses seldom contract the disease. Generally it is distributed indirectly, the person who contracts the disease having in some way swallowed some of the germs derived from a previous case.

The disease is now generally believed to be due to a schizomycete known as *Bacillus typhosus*. This germ causes ulcers on the intestinal walls and also multiplies in other organs of the body, notably the spleen and kidneys. The virus of the disease, i. e., the germ, is discharged from the body in great quantities through the bowels and also through the kidneys, and the discharges from these organs are the source of subsequent infections in other persons. The disease is usually contracted by drinking infected water, but may also be acquired through infected milk, salads, or other uncooked foods. Many wells, springs, and small streams are infected for longer or shorter periods, especially during the autumn and early winter. It is not safe to drink at such places without certain knowledge of the conditions.

Some very severe epidemics of typhoid fever have been definitely traced to contaminated water supplies, both in this country and in Europe. For instance, in an outbreak at Plymouth, Pa., more than a thousand cases of disease resulted in a small community from throwing out the bowel and kidney discharges of a patient upon frozen soil in the vicinity of a stream from which the town was furnished with water. A spring rain washed these discharges into the stream, and soon after the whole community was infected.

The danger from milk is not due to contamination from the cow, because cattle do not suffer with the disease. Milk is infected only when contaminated water is used dishonestly to dilute it, or when the pails and cans are washed inadvertently with such water, or when the germs enter it from the hands or other parts of the body of persons who either expel them chronically or who have been associated with active cases of typhoid. One great danger about milk is that typhoid germs multiply actively in it without perceptibly changing its appearance. Some years ago at Harpers Ferry an outbreak of 15 or 20 cases of typhoid fever was traced to one milkman whose daughter was very ill of typhoid. This man nursed the daughter, milked the cows, washed the cans, and delivered the milk. Typhoid sprang up all along the milkman's track.

It is believed that the common house fly frequently carries on its body from filthy places the germs of typhoid fever and deposits them on food in kitchens and on dining tables. Those who nurse the sick and are careless about disinfection frequently infect themselves by soiling food or drink with their dirty hands. The fingers should not be put into the mouth, the sick should not be kissed, and the utensils used in the sick room, such as plates, spoons, etc., should be reserved for the sick and thoroughly scalded on removal from the room. The time between infection and the appearance of the disease is usually from 9 to 14 days.

The number of cases in the registration area of the United States every year amounts to about 130,000, and the deaths amount to 13,000, while in the entire United States it is estimated that there are about three times this number.

In 20 years (1890–1909) in the English army in India there were 26,510 cases of typhoid fever and 6,494 deaths.

The proportion of deaths to cases varies from 10 per cent or less in light epidemics to 30 per cent or more in severe ones.

The best methods of avoiding the disease may be grouped under two heads: Personal hygiene and preventive inoculation.

SANITARY MEASURES.

When one is compelled to live in a house or in a neighborhood where typhoid fever prevails he should make it his infallible rule to eat and drink only such foods as have been recently heated to above the scalding temperature. Salads should be avoided, and water and milk should always be scalded before use. Fruits should be pared. The typhoid-fever organism is very susceptible to heat, and slight boiling or even a good strong scalding is sufficient to destroy it. So far as possible the house fly should be screened out of the house, while any that gain access should be diligently pursued and destroyed. A bit of wire netting attached to a wooden handle is a convenient weapon. If these measures were consistently practiced a large part of the now generally prevalent typhoid fever could be prevented, especially if in conjunction with these measures the discharges of the sick were consistently and thoroughly disinfected before being thrown out upon the soil or into latrines.

In many cases the typhoid organism persists in the bowel discharges and in the urine for quite a number of weeks after recovery, so that great care should be taken for a month or two that these discharges are not allowed to contaminate soil or water. In the case of a few unfortunates known as typhoid carriers, the organism becomes acclimated, and these persons then are a source of constant danger to their fellows.

To bowel and kidney discharges should be added an equal volume of 5 per cent carbolic acid solution (poison) or 5 per cent solution of liquor cresol compound (United States Pharmacopœia). Soiled linen should be put at once into boiling water. Soiled hands should be washed for five minutes in mercuric chloride water (1:1000) colored with methylene blue to distinguish it from ordinary nonpoisonous fluids and kept out of reach of children and animals. Tablets of this character are on the market. In no case should mercuric chloride solution be put into metallic vessels, as it soon becomes inert.

Owing to the difficulty of carrying out these sanitary precautions in localities where house flies swarm and bad water is prevalent and the local sanitary conditions are unknown, it is advised that field men receive preventive inoculation. This advice will hold for all well persons who find themselves in such situations.

VACCINATION AGAINST TYPHOID FEVER.

Typhoid fever is a self-limited disease. By this it is meant that if the patient does not die during the progress of the disease the body reacts against the invading micro-organisms with the production of various antibodies known as agglutinins, opsonins, etc., and these antibodies limit the disease to a variable number of weeks, after which the person recovers and the virus (the germ) disappears from the body.

The preventive inoculation for typhoid depends upon this fact. In recent years it has been discovered that by injecting under the skin a small quantity of a dead typhoid culture of known strength the body would react against these organisms in the same way as against the living bacteria in the bowels, and with the same result, namely, the increase in the body of antibodies which persist for a considerable period, rendering the person resistant to the disease.

This method has now been practiced on a large scale, chiefly in the armies of various nations, with striking results. It failed in the English Army during the Boer war, when there occurred 57,684 cases of typhoid fever and 8,020 deaths. But the cause of this failure is now well known. It was supposed at that time that the inoculated men were protected by the inoculation, but it is now known that the temperature at which the typhoid cultures were killed for these inoculations was too high (60 to 65° C.). It has been demonstrated repeatedly since that date that cultures killed at this high temperature lose almost all their protective power, and the bacterial cultures now used are sterilized at a temperature 10° lower (53° C. for 1 hour).

But in other places, for instance in the Japanese Army at the time of the Japanese-Russian war, the results were very striking. The Russian Army was largely incapacitated by fever, while the Japanese Army had practically no cases of fever.

Recently in the British Army in India typhoid inoculation has been practiced on a large scale, and very careful records have been kept of all the cases occurring among about equal numbers of non-inoculated and inoculated soldiers in the same regiments and subject to the same conditions. We now have records for 20 such regiments, and they show that even including one regiment which was inoculated with cultures heated too high the troops which had been inoculated have suffered very little from typhoid in comparison with the uninoculated.

If we exclude this one regiment and consider the regiments inoculated with cultures subjected to a minimum quantity of heat, there have been about ten times as many cases among the noninoculated as among the inoculated troops. If we include this regiment, about five times as many cases occurred in the uninoculated. In 20 of these regiments there have been 16 cases and no deaths from typhoid fever among the inoculated men (8,754) and 68 cases with 14 deaths among the uninoculated men (7,376).

Similar striking results in the United States Army have been obtained in recent years. Inoculations have been made compulsory, and everybody has been inoculated, from the Secretary of War down. It is a well-known fact that, previous to this, typhoid fever caused extensive loss in our Army, both in our Civil War and in the Spanish-American War. For example, in 1898, in the Seventh Army Corps, stationed at Jacksonville, Fla., consisting of 10,759 men, there were 1,729 undoubted cases of typhoid fever, and 2,693 additional cases of fever believed to be typhoid, making a total of 4,422 cases, with 248 deaths. In the recent maneuver at San Antonio, Tex., there were 12,801 men, all inoculated. Among these men there was only 1 case of typhoid fever, no deaths. In addition there were 2 cases of typhoid fever among civilian teamsters who refused to be inoculated. The 1 case in the Army was a sergeant who received only two doses of the prophylactic, three being the proper number. His disease was so mild that it was only identified as typhoid by means of blood cultures, after the rule had been established to examine all cases of fever lasting more than 48 hours. During this period 49 cases of typhoid and 19 deaths were reported among the citizens of San Antonio. At Galveston, Tex., where a lesser number of troops were also stationed, there were 192 cases of typhoid fever among the citizens and not a single one among the inoculated soldiers. In both San Antonio and Galveston, the troops had large freedom of visiting the towns, and it is quite certain that cases would have developed in the Army but for the inoculations.

Various commissions on antityphoid vaccination have been appointed in England, Germany, France, and the United States to report upon the status of this prophylactic measure, and without exception the conclusions adopted have been to the effect that antityphoid vaccination is useful, without danger, and provides a simple method of diminishing the frequency of typhoid fever.

Old people and very young persons are little subject to typhoid fever. Inoculation is not, therefore, deemed necessary for these classes, and in general for civilians who live at home and are able to care for themselves properly. Neither is it advised for people in ill health. But for well persons exposed to the dangers of field service it is urgently advised that the regulation three inoculations of the United States Army be taken. These should be given always by a competent physician, never by the person himself.

The first dose consists of ½ c. c. (7½ minims), the second and third doses of 1 c. c. (15 minims) of a young sterilized typhoid culture. The inoculations are made at intervals of 10 days; the entire course thus requires 20 days. The inoculation is always made under the skin, never into the skin nor into the muscle. The site usually selected is the arm at the insertion of the deltoid muscle. The arm should be cleaned as for any other operation. The Surgeon General's Office recommends washing the arm in tincture of iodine diluted in an equal volume of alcohol, and states that this method of disinfection has proved satisfactory. The skin is painted with the iodine before and after the hypodermic injection.

The inoculating material is sent in a small glass tube, the surface of which should be washed with an antiseptic before it is opened. It may then be entered by making a few cuts at the top with a clean file. The syringe used should be thoroughly sterilized by boiling immediately before use. The inoculating material should preferably be drawn out of the container by means of the syringe. If it is emptied out into anything else beforehand that receptacle must be sterilized in advance. The syringe and needle should be sterilized by boiling in 2 per cent soda solution. It is best to sterilize the piston separately so that the full length of the barrel shall be exposed to the boiling water. A fresh needle must be used on each man, or if not, it must be plunged in the boiling soda solution to resterilize it.

The most suitable time for administration is about 4 o'clock in the afternoon, as the greater part of the reaction is then over before morning. As already stated, no applicant should be immunized who is not perfectly healthy and free from fever at the time. In case of any man who has fever the inoculation should be postponed until he recovers. This precaution is necessary in order to avoid its administration to men who may be coming down with typhoid or other fevers. It is strongly advised not to drink beer or other alcoholic liquors during and for a day or two after inoculation.

The reaction from the inoculations are two: A moderate local swelling, and a slight general fever. These are of shorter duration and usually much less severe than similar inoculations for smallpox. The entire reaction is over in 48 hours, and during this time severe labor should be avoided. It is stated by the Surgeon General's Office that no untoward results of any kind have ever been noted.

Any of the prophylactic remaining unused should be thrown away, and a fresh vial opened for the day's use. It should be stored in the ice box. Nothing is gained by making the inoculations at closer intervals than the 10 days. The production of large quantities of antibodies does not become evident until 8 or 10 days after the inoculation. It is not believed that there is any increased susceptibility following the first dose, but that increased resistance begins immediately, although the degree of immunity produced is not very high until after a lapse of 10 days.

Women and children should receive doses according to body weight, taking 150 pounds as the unit. The Widal reaction is always positive after the typhoid inoculation. It appears within 10 days after the first dose, and is stated by the Surgeon General's Office to remain positive for six months or a year. Col. Leishman, who has had charge of the preventive inoculation in the British Army in recent years, states that the period of protection lasts for two years and in some cases considerably longer.

The prophylactic will keep, it is said, for six months if stored at a low temperature in the dark, but it is desirable in all cases to use it soon after preparation and to obtain fresh supplies rather than depend upon old stock.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a member of Congress or the Secretary of Agriculture.]

○

Issued January 8, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 479.

Experiment Station Work,

LXVII.

Compiled from the Publications of the Agricultural Experiment Stations.

SCREENING CABBAGE SEED BEDS.
SPRAYING APPLE ORCHARDS.
NEW TYPE OF SPRAY NOZZLE.
PREPARATION OF CORN FOR HOGS.
EXPERIMENTS IN BEEF PRODUCTION.
PREPARATION OF CHOICE HAMS.
FACTORS AFFECTING FAT IN CREAM.

NOVEMBER, 1911.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

THE AGRICULTURAL EXPERIMENT STATIONS.

- ALABAMA—
  - College Station: *Auburn;* J. F. Duggar.[1]
  - Canebrake Station: *Uniontown;* L. H. Moore.[1]
  - Tuskegee Station: *Tuskegee Institute;* G. W. Carver.[1]
- ALASKA—*Sitka:* C. C. Georgeson.[2]
- ARIZONA—*Tucson:* R. H. Forbes.[1]
- ARKANSAS—*Fayetteville:* C. F. Adams.[1]
- CALIFORNIA—*Berkeley:* E. J. Wickson.[1]
- COLORADO—*Fort Collins:* C. P. Gillette.[1]
- CONNECTICUT—
  - State Station: *New Haven;* E. H. Jenkins.[1]
  - Storrs Station: *Storrs;* L. A. Clinton.[1]
- DELAWARE—*Newark:* H. Hayward.[1]
- FLORIDA—*Gainesville:* P. H. Rolfs.[1]
- GEORGIA—*Experiment:* Martin V. Calvin.[1]
- GUAM—*Island of Guam:* J. B. Thompson.[2]
- HAWAII—
  - Federal Station: *Honolulu;* E. V. Wilcox.[2]
  - Sugar Planters' Station: *Honolulu;* C. F. Eckart.[1]
- IDAHO—*Moscow:* W. L. Carlyle.[1]
- ILLINOIS—*Urbana:* E. Davenport.[1]
- INDIANA—*La Fayette:* A. Goss.[1]
- IOWA—*Ames:* C. F. Curtiss.[1]
- KANSAS—*Manhattan:* E. H. Webster.[1]
- KENTUCKY—*Lexington:* M. A. Scovell.[1]
- LOUISIANA—
  - State Station: *Baton Rouge;*
  - Sugar Station: *Audubon Park, New Orleans;*
  - North La. Station: *Calhoun;*
  - Rice Station: *Crowley;*
  - W. R. Dodson.[1]
- MAINE—*Orono:* C. D. Woods.[1]
- MARYLAND—*College Park:* H. J. Patterson.[1]
- MASSACHUSETTS—*Amherst:* W. P. Brooks.[1]
- MICHIGAN—*East Lansing:* R. S. Shaw.[1]
- MINNESOTA—*University Farm, St. Paul:* A. F. Woods.[1]
- MISSISSIPPI—*Agricultural College:* J. W. Fox.[1]
- MISSOURI—
  - College Station: *Columbia;* F. B. Mumford.[1]
  - Fruit Station: *Mountain Grove;* Paul Evans.[1]
- MONTANA—*Bozeman:* F. B. Linfield.[1]
- NEBRASKA—*Lincoln:* E. A. Burnett.[1]
- NEVADA—*Reno:* J. E. Stubbs.[1]
- NEW HAMPSHIRE—*Durham:* J. C. Kendall.[1]
- NEW JERSEY—*New Brunswick:* J. G. Lipman.[1]
- NEW MEXICO—*Agricultural College:* Luther Foster.[1]
- NEW YORK—
  - State Station: *Geneva;* W. H. Jordan.[1]
  - Cornell Station: *Ithaca;* L. H. Bailey.[1]
- NORTH CAROLINA—
  - College Station: *West Raleigh;* C. B. Williams.[1]
  - State Station: *Raleigh;* B. W. Kilgore.[1]
- NORTH DAKOTA—*Agricultural College:* J. H. Worst.[1]
- OHIO—*Wooster:* C. E. Thorne.[1]
- OKLAHOMA—*Stillwater:* J. A. Wilson.[1]
- OREGON—*Corvallis:* J. Withycombe.[1]
- PENNSYLVANIA—
  - *State College:* T. F. Hunt.[1]
  - *State College:* Institute of Animal Nutrition, H. P. Armsby.[1]
- PORTO RICO—
  - Federal Station: *Mayaguez;* D. W. May.[2]
  - Sugar Planters' Station: *Rio Pedras;* J. T. Crawley.[1]
- RHODE ISLAND—*Kingston:* H. J. Wheeler.[1]
- SOUTH CAROLINA—*Clemson College:* J. N. Harper.[1]
- SOUTH DAKOTA—*Brookings:* J. W. Wilson.[1]
- TENNESSEE—*Knoxville:* H. A. Morgan.[1]
- TEXAS—*College Station:* B. Youngblood.[1]
- UTAH—*Logan:* E. D. Ball.[1]
- VERMONT—*Burlington:* J. L. Hills.[1]
- VIRGINIA—
  - *Blacksburg:* S. W. Fletcher.[1]
  - *Norfolk:* Truck Station, T. C. Johnson.[1]
- WASHINGTON—*Pullman:* R. W. Thatcher.[1]
- WEST VIRGINIA—*Morgantown:* J. H. Stewart.[1]
- WISCONSIN—*Madison:* H. L. Russell.[1]
- WYOMING—*Laramie:* H. G. Knight.[1]

---

[1] Director.

[2] Special agent in charge.

EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

CONTENTS OF NO. LXVII.

Page.

Screening cabbage seed beds 5

Does it pay to spray apple orchards? 8

  Cost of spraying 9

  Results of spraying 9

A new type of spray nozzle 10

Preparation of corn for hogs 11

Experiments in beef production 12

  Introduction 12

  Steer feeding as an aid in maintaining soil fertility 13

  "Baby beef" experiments 13

  Influence of age and condition of the animal 15

  Efficiency of different types of steers 15

  Use of a self-feeder for short-fed steers 16

  Supplements to pasture in Missouri 16

  Bulky versus concentrated rations 17

  A test of hays for winter feeding 18

  Cost of beef production in the South 18

  A feeding test in the Northwest 19

Preparation of choice hams 19

  Curing 19

  Cooking 22

Factors affecting the percentage of fat in cream 22

ILLUSTRATION.

Page.
Fig. 1. A new type of spray nozzle adapted to high-pressure work on large trees — 10

EXPERIMENT STATION WORK.[1]

SCREENING CABBAGE SEED BEDS.[2]

Root maggots (*Pegomya* spp. *et al.*) often cause serious destruction to cabbage seedlings by attacking the underground portion of the plant. A number of methods for the prevention and control of root maggots have been employed and are described in a circular of the Bureau of Entomology of the United States Department of Agriculture.[3] A serious outbreak of these pests is at the best difficult to combat. The amount of damage done varies from year to year and is most serious in northern sections, where late cabbages are grown, since the seed beds are started in the open in April or May when other food supply for the maggots is apt to be scant.

In a recent bulletin of the New York State station, Mr. W. J. Schoene describes the work of root maggots in cabbage in central New York as follows:

> The adults of the cabbage maggot appear about May 15 and oviposit about [the] plants. The eggs are found in large numbers from May 20 to June 5. On hatching, the larva attack either the stalk or the roots of the plant. The newly hatched larva is less than one-twentieth of an inch long, and the injury to the plant is at first slight and does not become important until the maggot is 8 or 10 days old. In the latitude of Geneva the maggot work becomes conspicuous about June 15, and generally the grower is not aware of the presence of the insects in injurious numbers until many of the plants are killed.
>
> The injury to the plant depends upon its size, the weather, and the number of insects feeding upon the roots. The members of the cabbage family are very thrifty and, other conditions being favorable, will outgrow considerable injury. However, if the plant is small or the maggots numerous, as is frequently the case, the root is entirely destroyed. The number of seedling plants that are spoiled for transplanting in a moderate infestation depends upon the weather. A period of dry weather and a few maggots will destroy a seed bed as quickly and completely as a bad infestation accompanied by more favorable weather conditions.

Root maggots did so much damage to seed beds around Seneca Castle, N. Y., in 1906 that the New York State station undertook some cooperative experiments in that region in the following season to determine the value of screening with cheesecloth as a means of protection against the maggots and to ascertain methods by which plants could be grown under frames without appreciably reducing their vitality for transplanting purposes. The results of these initial experiments, as reported in a former bulletin of the station,[1] were so successful that the number of cabbage growers in the above locality who have used cheesecloth to protect at least a portion of their plantings has increased each season. In 1910 a large proportion of the plants were started under screens. The station has thus been afforded abundant opportunity to study the details of raising plants in screened frames and to determine upon the practicability of this method of protection.

---

[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[2] Compiled from New York State Sta. Bul. 334.

[3] U. S. Dept. Agr., Bureau of Entomology Circ. 63.

After observing practical tests with cheesecloth during a period of four years, Mr. Schoene reports that the use of cheesecloth is entirely practicable; the cost of screening in a number of operations ranging from 6 to 20 cents per thousand plants. The maggots were completely controlled, and certain grades of cheesecloth also prevented injury by the turnip flea beetle (*Phyllotreta vittata*), a less important but at times serious pest, which gnaws round holes in the young plants and is often controlled by very frequent applications of tobacco dust or by one of the arsenical sprays.

During the four years that screens have been employed for the protection of cabbage plants much has been learned regarding their use: (1) If the cheesecloth is carefully attached and the frame is tight, injuries by the maggot can be entirely prevented; (2) the work of the flea beetles may be partially or wholly avoided, depending on the grade of cloth used for the screen; and (3) the screen conserves the moisture and prevents baking of the soil between seeding time and the period when the plants are of such a size as to permit cultivation.

Before the plants are of the desired size to set in the field they are very susceptible to changes in moisture and temperature. The young cabbage plants are shallow-rooted and very tender. They do not thrive in dry or cool weather, and they are also liable to be injured by a heavy rain, lack of cultivation, and weeds. Thus the conditions of growth that surround the plant are oftentimes of more importance than is realized by the farmer, and the great difference in the growth of the plants covered by cheesecloth and those not protected is to be attributed in part to the fact that the conditions for growth under the screen are more congenial.

In most seasons screened plants grow faster and obtain the size desired earlier than plants not screened. The difference in the size of the plants screened and not screened is very apparent in early seedlings where the seed is planted during April or the first part of May. In later plantings the difference is not so marked, and now and then the plants in the open grow just as fast and make more desirable seedlings. In addition to the larger size of the plants, shade has the general effect of reducing the actual weight of dry matter stored in the plants; that is, shading makes plants more succulent. The temperature and moisture conditions produced by cheesecloth shade are well known.

---

[1] New York State Sta. Bul. 301.

> In general the effect of screening is to reduce sunlight and air circulation and to raise the temperature both of the air and soil. Thus we have two opposing factors: One, the shade tending to decrease the rate of growth, and the other, a higher temperature and more favorable moisture conditions, having the opposite effect. * * * It is probable that the increase of the temperature and moisture is more important than the reduction in sunlight and that the screened plants will always make a faster growth except when the optimum conditions of light, temperature, and moisture obtain in the open, which rarely happens in this latitude during May and the first two weeks of June.

Various grades of cheesecloth ranging from 17 to 50 threads to the inch were used during the four years. They were all effective in preventing injury by maggots, and the only flea-beetle injury noticed was in beds under the 17-thread cloth. This grade of cloth easily stretches out of shape in tacking it to the frame, while plants grown under the closely woven 50-thread cloth have shown slight tendency to be spindling. The cloth having from 20 to 30 threads to the inch is preferred for the purpose of protecting the seedlings. Furthermore, these grades handle easily in putting them on and taking them off the frame. When grown under such screens the plants compare very favorably in stockiness with those grown in open beds, and they are not so liable to the attacks of flea beetles. Although the screened beds are more liable to mildew and other fungus diseases than the open beds, no serious outbreaks of any disease occurred during the four years.

Some growers prefer to screen their seed beds in order to get plants for early setting, since the cabbage harvested first in the fall frequently brings a better price than the main crop.

Although these experiments were conducted in central New York, the following suggestions are applicable to a much larger area, since cabbage maggots are the cause of more or less serious loss year after year throughout the northern tier of States and Canada. It should be borne in mind, however, that the time when the adult maggots appear will vary for different localities.

> The seed bed should be located on a fertile, well-drained soil, where there can be no accumulation of water or washing under the frame by rains. It is also desirable to locate the bed on land known to be free from weeds and injurious insects such as wireworms and white grubs. The ground should certainly be free from the disease known as club root. The soil should be thoroughly cultivated so that it is in good physical condition at seeding time. It is customary to apply liberal amounts of high-grade commercial fertilizer. The seed should be drilled rather thickly, in rows 6 or 8 inches apart. When the early varieties of cabbage are to be grown, the seed should be planted during the first part of May or even earlier, whereas such varieties as Danish should be planted about May 15. Before the seed is drilled, the corners of the bed should be staked, so that the frame can be built and the cheesecloth applied before the plants come up. This is important as the cloth prevents the soil from baking and conserves the moisture; also, if the screening is delayed until after the plants come up, the plants are subject to injury by the flea beetle.

Six-inch boards will serve for the frame, though some growers use 8 and 10 inch boards with satisfaction. The cloth should not sag and rest on the plants. This may be prevented by stretching several lengths of wire from end to end of the bed. The wires should not be more than 4 or 5 feet apart. The wire can be supported on stakes, to which it is held by staples. It is preferable that galvanized wire and staples be used, as rusty wire wears holes in the cloth at the point of contact. All openings under the frame, due to unevenness in the soil, should be filled by banking the earth against the boards. To harden the plants so they will not wilt beyond recovery when set in the field, the cheesecloth should be removed a week or 10 days before transplanting. It is well to examine the soil about the plants at intervals of several days after they have been uncovered to ascertain if eggs are being deposited. If the eggs are numerous the plants should be transplanted as soon as possible, the earth being shaken from the roots, which will dislodge most of the eggs or young maggots. When the plants have reached a desirable size they should be transplanted, as they are liable to grow too long and spindling.

DOES IT PAY TO SPRAY APPLE ORCHARDS?[1]

Results recently reported by R. A. Emerson and others of the Nebraska station furnish a valuable illustration of the profitableness of thorough spraying as a regular orchard practice. In 1906 the experiment station, in cooperation with this department, began a series of spraying demonstrations in eastern Nebraska apple orchards. During the five years that these experiments have been continued demonstrations have been made in 22 orchards, representing 18 localities in 13 counties.

Before the work was begun it was well known that it was possible by proper spraying to control scab and codling moth, the most generally troublesome pests of apple orchards in Nebraska. There was available, however, very little definite information regarding the cost of spraying or the profits to be derived from it under our conditions. The majority of farmers made no attempt at spraying. Many of the more prominent commercial orchardists, even, were trying to produce apples without spraying, and those who were spraying more or less regularly were, with few exceptions, not sufficiently thorough in their work to get the best results. On account of the lack of knowledge of the proper means to employ in combating the common orchard pests, many orchardists had come to believe that apple growing was not a profitable business; and under the conditions prevailing in many orchards, this was a perfectly correct conclusion.

It was therefore planned from the start not merely to demonstrate the possibility of controlling apple insects and diseases but also to determine whether they could be controlled profitably. * * *

The work was done under all sorts of conditions. The trees varied in age from 10 to 28 years and averaged about 18 years. In some orchards they had been well pruned, but in more cases they had been pruned little or not at all for some years. In some cases the spraying was hindered by the closeness of the trees and in others by a secondary crop of bush fruits. In some orchards, on the other hand, the trees were conveniently spaced and the ground was free from troublesome bushes. A few orchards had almost every convenience for mixing and applying the spray materials while others were almost completely without such conveniences. * * *

---

[1] Compiled from Nebraska Sta. Bul. 119.

On the whole it may be said that these spraying demonstrations were conducted not under ideal conditions but under conditions fairly representative of eastern Nebraska orchards, and that, therefore, conclusions rightly drawn from the work should be of value to orchard owners in that part of the State. The results were not exceptionally good. In fact, the up-to-date orchardist should be able to get, and does get, better results than those reported here.

The following statements give a summary of the results obtained from the first four years' work:

COST OF SPRAYING.

Number of orchards sprayed, 16.
Total number of trees sprayed, 3,300.
Average age of trees, 18 years.
Average number of sprayings per year, 4.
Average quantity of spray per tree each year, 13 gallons.
Average quantity of spray per acre (50 trees), 650 gallons.
Average cost of spray material per 100 gallons, 87 cents.
Average cost of applying spray per 100 gallons, 98 cents.
Average total cost of spraying per 100 gallons, $1.85.
Average annual cost of spray material per tree, 11.3 cents.
Average annual cost of applying spray per tree, 12.7 cents.
Average total annual cost of spraying per tree, 24 cents.
Average total annual cost of spraying per acre (50 trees), $12.

RESULTS OF SPRAYING.

Average annual yield and net value per tree:		
Sprayed trees—		
Marketable fruit (4.4 bushels at 52 cents)	$2.28	
Culls and windfalls (1.1 bushels at 6 cents)	.07	
Total (5.5 bushels at 43 cents)		$2.35
Unsprayed trees—		
Marketable fruit (1.8 bushels at 41 cents)	0.73	
Culls and windfalls (1.7 bushels at 5 cents)	.08	
Total (3.5 bushels at 23 cents)		.81
Difference between sprayed and unsprayed trees		1.54
Average cost of spraying		.24
Average net gain from spraying		1.30
Average annual yield and net value per acre (estimated on basis of 50 trees):		
Sprayed trees—		
Marketable fruit (220 bushels)	$114.40	
Culls and windfalls (55 bushels)	3.30	
Total (275 bushels)		$117.70
Unsprayed trees—		
Marketable fruit (90 bushels)	36.90	
Culls and windfalls (85 bushels)	4.25	
Total (175 bushels)		41.15
Difference between sprayed and unsprayed trees		76.55
Average cost of spraying		12.00
Average net gain from spraying		64.55

Whether it pays to spray apple orchards in eastern Nebraska is no longer a question. The records reported here—records secured under actual farm conditions—show that spraying pays twice its cost by increasing the yield of fruit and three times its cost by improving the quality of the fruit, or six times its cost by both increased yields and improved quality. The gain due to spraying one-half acre of apples one year will, on the average, buy a good barrel-pump, 50 feet of hose, 2 extension rods, 2 nozzles, and 5 barrels for use in mixing spray materials. The sprayer will last several years and can be used to fair advantage in orchards up to 5 acres. The gain from the proper spraying of 5 acres one year will, under average conditions, pay for a power outfit, including a small gasoline engine, pumps, rods, nozzles, hose, 250-gallon spray tank, elevated spray platform, and the truck on which to mount the whole outfit. One such power sprayer is ordinarily sufficient for an orchard of 20 acres and is often used in orchards of more than twice that size. The question of whether one can afford to spray has been answered. It would not be so easy to determine how anyone who owns an orchard can afford not to spray.

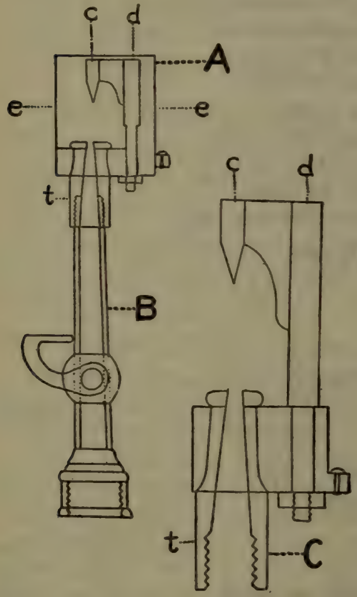


FIG. 1.—A new type of spray nozzle adapted to high-pressure work on large trees.

These results and conclusions apply specifically to eastern Nebraska, but it is believed that they are worthy of serious consideration wherever thorough spraying is not a regular orchard practice.

A NEW TYPE OF SPRAY NOZZLE.[1]

The effectiveness of spraying depends in large measure upon the character of the nozzle used, and it is especially important that the nozzle should be adapted to the specific purpose for which it is to be used. G. E. Stone, of the Massachusetts station, has devised a nozzle which he has used with very satisfactory results in spraying large trees from a high-pressure machine.

This nozzle is shown in figure 1, at *A*. It consists of a nozzle screwed tightly onto the tip of a standard attachment provided with shut-off, such as is often employed in spraying work. (See *B*.) The attachment, however, is incidental, as it may be fitted to any suitable metal connection threaded to fit, and provided with a hose connection at the lower end. The essential part of the nozzle, as shown at *A*, consists of a small brass tip, *t*, about 1½ inches long, provided with an aperture at the end ⅛ of an inch in diameter, although sometimes an aperture of $\frac{5}{32}$ or $\frac{3}{16}$ of an inch in diameter has been employed. About an inch or more above the center of the aperture there is placed a solid brass rod, *c*, ¼ of an inch in diameter. This is attached to another rod, *d*, by means of a thin sheet of brass; the rod *d* works in a socket and allows the pointed brass rod *c* to be thrown in or out of center at will. The object of this center brass rod, *c*, is to take the spray as it comes out of the ⅛-inch nozzle under high pressure and break it up into a fine mist, and with the pressure which we used it is capable of throwing the mist 20 or 25 feet. This is sufficient to reach, from a ladder, most of the foliage on a large elm tree. In case it is necessary to reach higher, the adjustment is thrown out of the center and the spray goes directly through the ⅛-inch aperture. By this means a greater distance and carrying power are secured, although not so fine a spray.

---

[1] Compiled from Massachusetts Sta. Rpt. 1910, pt. 2, p. 69.

In the drawing the nozzle is shown surrounded by a shield, *e*, which was for the purpose of protecting the point, *c*. The nozzle as originally constructed was not provided with a shield, being used for some days without it, but with the hard usage which it received [it was] found that the adjustment was likely to be injured. The nozzle was used in connection with a machine giving 250 pounds pressure, and the spraying mixture was carried through a 1-inch hose.

This nozzle was used * * * in spraying over 1,000 trees having an average diameter of about 22 inches. Careful estimates made showed that the average amount of arsenate of lead per tree was 1.7 pounds, or about 17 gallons of arsenate of lead in solution. The cost of spraying each tree, including the labor, gasoline, and lead, was 55 cents.

The spraying was just as thorough and the cost was about one-third of that by the ordinary method, using Vermorel and other fine-mist nozzles.

PREPARATION OF CORN FOR HOGS.[1]

The question of the most economical method of feeding corn to hogs has been very carefully studied by W. J. Kennedy and E. T. Robbins, of the Iowa Experiment Station. There has been much difference of opinion on this question and the results of previous experiments have not always been consistent.

Among the farmers the time-honored way of feeding corn to hogs is to shovel it to them directly from the crib. The keen appetite shown for dry-ear corn fed in this simple manner does not indicate that hogs are especially in need of having their corn prepared for them in any way. Still, many careful, progressive feeders, men who are ever watchful for the comfort and thrift of their stock, have come to feel that the simple form in which corn is supplied by nature can be improved. The grinding and soaking of corn are thus given an influential degree of support because so many of the best pure-bred hogs in the country are fed their corn thus carefully prepared.

While previous experiments vary in their results and in their adaptability to practical conditions, there are many cases in which a distinct advantage has followed the grinding and soaking of corn for hogs. Cooking has long since been shown to be not only a waste of time and fuel, but an actual detriment to the nutritive qualities of the grain. The evidence against it is at once consistent and emphatic. The variability of results with grinding and soaking have suggested that, while there may be certain circumstances under which they may be useful, there must surely be some cases in which they are a waste of time and money, even if they do not actually decrease the feeding value of the corn for hogs.

---

[1] Compiled from Iowa Sta. Bul. 106.

In the Iowa experiments comparisons of dry-ear corn, soaked shelled corn, dry and soaked corn meal, and dry and soaked corn-and-cob meal were made on 312 hogs of all ages.

The results clearly indicate the most profitable farm practice where corn was the main part of the ration for hogs. The fastest and most profitable gains were secured by feeding dry-ear corn until the hogs were close to 200 pounds in weight. The scoop shovel was all that was needed to prepare corn for them. Then if the hogs were to be fed longer, and the weather permitted, the most profitable gains were secured by changing them to soaked shelled corn. Spring pigs to be sold the next fall and winter thus gave the best results when fed dry-ear corn until sold. Fall pigs and the spring pigs carried over to be fattened the following spring were handled most profitably by feeding dry-ear corn until the weather became mild enough for soaking corn in the following spring, and then feeding soaked shelled corn until the finish. This was especially true when the hogs were run on pasture. The old sows made faster and more economical gains on dry corn meal than on ear corn, but the benefit from this was largely lost when it was finally necessary to ship them to market on ear corn. They were handled most profitably by feeding soaked shelled corn. It should be borne in mind that corn soaked 12 hours gave better results than that soaked 24 hours. * * *

It proved useless to grind corn for hogs of any age when the weather was warm enough to permit soaking. In every case, where grinding has shown a saving of corn, simple soaking 12 hours in water has shown a still greater saving. * * *

In general, hogs that had been accustomed to corn prepared in some form received at least a temporary check in rate and economy of gains when for any reason a change was made to dry-ear corn. When the gains had been very rapid on the soaked or ground corn this effect was more marked and in some cases offset any beneficial effect of the preparation of the corn.

These experiments indicate, therefore, that grinding corn for hogs is as a rule unnecessary and unprofitable, although soaking may be of advantage under certain circumstances. The simplest and most profitable method in most cases is to feed dry ear-corn with a scoop shovel.

EXPERIMENTS IN BEEF PRODUCTION.[1]

INTRODUCTION.

The cutting up of the open ranges into farms means that in the future a large part of the beef produced in the United States will come from animals bred, fed, and finished in the same locality. Though cattle may not make as cheap gains as sheep or hogs, yet where there are large quantities of roughage at the disposal of the feeder beef can be produced on high-priced lands in the corn belt.

---

[1] Compiled from Alabama College Sta. Buls. 150, 151; Illinois Sta. Bul. 142; Indiana Sta. Buls. 142, 146; Michigan Sta. Bul. 261; Missouri Sta. Bul. 90; Montana Sta. Bul. 78; Nebraska Sta. Buls. 116, 117; Pennsylvania Sta. Bul. 102; Rpt. 1909, pp. 146–153; Tennessee Sta. Bul. 79; Rpt. 1908, pp. 116–118; U. S. Dept. Agr., Bur. Anim. Indus. Bul. 131; Canada Expt. Farms Rpts. 1910, pp. 75–87; Proc. Soc. Prom. Agr. Sci., 30 (1909), pp. 70–98.

Recent work at the experiment stations in Indiana and Pennsylvania show that silage is an excellent feed for steers, and where its use can be extended into the summer the land commonly devoted to pasture can be reduced in area, an important factor where farm values are high. The requisites for the economical production of beef on high-priced lands are good breeding and good feeding, and because there are no cheap pastures the animal must be pushed from calfhood to the block, although it is not always necessary to market it as baby beef. Profitable beef production in the future means that steady gains must be made. This is possible where the finishing is done on the same farm where the calf is reared. The economic loss imposed by the shrinkage from the range to the feed lot can be avoided by the feeder who also is the breeder.

It is the purpose of this article to summarize recent results obtained in feeding steers at some of the experiment stations, which may be of value to those engaged in feeding and finishing cattle and who are seeking information on this point.

STEER FEEDING AS AN AID IN MAINTAINING SOIL FERTILITY.

One advantage in feeding steers on the farm is the maintenance of the soil fertility. This has been well demonstrated in experiments at the Tennessee station to test the feeding capacity of acre plats of corn, soy beans, and cowpeas, the manure in each case being returned to the plats, and the economy of this conversion of the crops into beef as compared with direct sale of the crops. In 1906–7 an acre of corn lasted 4 steers for 54 days and produced a gain of 129 pounds; an acre of soy beans lasted a similar lot of steers 80 days and produced a gain of 406 pounds; an acre of cowpeas lasted 54 days and produced a gain of 289 pounds. In 1907–8 the gains for the corresponding lots of steers were—for the corn lot, 203 pounds; the soy bean lot, 541 pounds; and the cowpea lot, 327 pounds. The results afford an excellent illustration of the advantage of growing and feeding legumes to steers from the standpoint of maintaining the fertility of the farm. By the return of manure from the feeding of crops there was a marked increase in the productiveness of the soil, especially in the case of soy beans, with which the feeding capacity for 4 steers per acre was increased from 80 days in 1905–6 to 100 days in 1908–9. The cost of growing the soy beans in these experiments was about $13 per acre.

"BABY BEEF" EXPERIMENTS.

At the Michigan station feeding trials were made for several years to compare the relative profits of two methods of handling an ordinary grade beef herd. In one lot, which consisted of grade cows, the calves were nursed by their dams and also received supplementary feed. After weaning, they were finished and marketed as baby beeves at 18 months of age. In another herd, consisting also of 10 grade cows, the calves were reared on skim milk and supplementary feed, and finished and marketed with the other lot, their dams being milked. The results obtained indicate that—

> Baby beef production by the skim-milk method is much cheaper and gives better results than by the suckling method.
>
> When marketed at an average age of 18 months, calves raised on skim milk weighed 966 pounds, while those that had suckled their dams weighed 995 pounds, which is not a wide difference in weight. The skim milk fed baby beeves cost $50.60 per head, while the suckled baby beeves cost $66.97 per head, a difference of $16.37 per head in favor of the former method. The skim milk baby beeves were produced for $5.23 per hundredweight as compared to a cost of $6.73 per hundredweight for the others, a difference in economy of production of $1.50 per hundredweight in favor of the skim milk fed animals. * * *
>
> The quality of the baby beeves produced by the two methods was practically the same and the skim milk lots brought the same prices as the suckled lots when put on the market. As noted before, the cost of production is undoubtedly higher than it would be under ordinary farm conditions, but nevertheless the figures as given show the comparative costs and values correctly and conclusions as to the methods of feeding may be safely drawn.

In a baby-beef experiment at the Canada experimental farms, 5 steers weighing 504 pounds each on a limited growing ration, in which the grain consisted of bran, gluten, oil meal, and corn, made in 393 days an average daily gain of 1.23 pounds per head at a cost of 5.5 cents per pound. In this case there was a loss of $2.04 per head. On the other hand, 6 steers weighing 593.3 pounds each, on a full fattening ration for 290 days, made an average daily gain of 1.61 pounds per head at a cost of 6.02 cents per pound. The average profit per head in this case was $5.19. Five calves dropped in 1907, weighing at the start about 84 pounds each, fed a limited growing ration, of which the grain consisted of bran, oil and gluten meals, oats, and corn, made an average daily gain for 729 days of 1.24 pounds per head at a cost of 4.66 cents per pound. There was an average loss per steer of $2.05. Six steers weighing 106 pounds each, on a full fattening ration containing the same ingredients, made an average daily gain in 626 days of 1.52 pounds per head at a cost of 4.88 cents per pound. The profit per head was $5.19.

In another experiment 4 yearlings, averaging 472.5 pounds in weight, fed for 190 days on a ration of clover hay, silage, roots, straw, bran, and gluten, made an average daily gain of 2.17 pounds per head at a cost of 5.73 cents per pound. The net profit per steer was $4.43. Nine steers, averaging 1,145 pounds in weight, fed for 100 days on the same ration with oil meal in addition, made an average daily gain of 2.77 pounds per head at a cost of 5.61 cents per pound. Three steers weighing 923 pounds each, on a grain ration of bran and ground corn for 70 days, made an average daily gain per head of 2 pounds at a cost of 8.15 cents per pound. The net profit per steer was $1.47. Three steers weighing 735 pounds each, on a grain ration of bran and oil meal for 70 days, made an average daily gain of 2.1 pounds per head at a cost of 7.19 cents per pound, and gave a profit per head of $1.26. Three steers weighing 837 pounds each, on a grain ration of bran, gluten, and oil meal for 70 days, made an average daily gain of 1.53 pounds per head at a cost of 9.9 cents per pound. There was a net loss of 12 cents per steer.

INFLUENCE OF AGE AND CONDITION OF THE ANIMAL.

J. H. Skinner and W. A. Cochel carried on a 3-year experiment with calves, yearlings, and 2-year-olds at the Indiana station to study the influence of age on the economy and profit of feeding for beef production. The results indicated that the intial cost per hundred pounds of meat produced was greater with the calves than with the older cattle; that the length of time necessary for finishing steers decreased with age; that the rate and the cost of gain and the proportion of roughage to concentrates consumed increased with age; and that the amount of gain necessary in finishing cattle of equal condition decreased as their age increased. The difference in total quantity of feed necessary for finishing cattle of different ages and fed to the same marketable finish was negligible.

The average margin required between buying and selling prices to prevent loss was $1.60 per hundred on calves, $1.71 on yearlings, and $1.55 on 2-year-olds; the margins secured on a stationary market were $2.02 on calves, $2.22 on yearlings, and $2.09 on 2-year-olds, resulting in a profit of 42 cents per hundred on calves, 51 cents on yearlings, and 54 cents on 2-year-olds.

The increase in live weight necessary to make calves prime was 103 per cent, yearlings, 54 per cent, and 2-year-olds, 43.6 per cent of their initial weights at the beginning of the feeding period.

At a uniform price for feeds the difference in cost of gains between calves and yearlings was $1.35, between yearlings and 2-year-olds, 28 cents per hundred pounds.

The experienced farmer who feeds cattle should handle older cattle in preference to calves, while the farmer who produces and finishes his own cattle may find calves more preferable.

EFFICIENCY OF DIFFERENT TYPES OF STEERS.

H. P. Armsby, of the Pennsylvania station, in cooperation with this department, compared the beef type with the scrub as a meat producer. A pure-bred Aberdeen-Angus steer 8½ months of age, and a steer 11 months old, of the dairy type, containing a large percentage of Jersey blood, were under observation over 2½ years. Both animals received similar rations, which consisted of hay, bran, and mixed grains. The live weight was frequently taken, and the digestibility of the total ration and the nitrogen balance were determined at intervals. The growth of the pure-bred steer was more largely in body girth, while the scrub steer increased relatively more rapidly in length and height, or, in other words, the pure-bred steer showed a tendency to fatten, while the scrub inclined to gain relatively more nitrogenous material. It is thought that the difference in temperament explained in large part the economic superiority of the beef type, for apparently "the two steers did not materially differ as regards digestive power, percentage of feed energy metabolized, or percentage availability of the feed energy."

> The pure-bred steer was superior to the scrub in that his maintenance requirement was less while his capacity to consume feed was greater. On the moderate rations fed, he manifested this superiority, however, not in the form of greater gain of live weight from a unit of food, but in the production of higher quality of product, representing the storage of more energy available as human food.

From a study of individuality H. R. Smith, of the Nebraska station, concludes that—

> Nearly all of the largest gainers * * * were steers which measured large middle girths at the beginning of the feeding period, and it would seem that size of middle girth is an important factor in determining future gains. In these experiments the size of bone did not seem to bear any definite relationship to rate of gain, some of the best gainers being large in bone and some relatively small; nor was there any definite relationship between heart girths and rate of gain, though the large majority of the best doers of the several groups were large in heart girth. With but few exceptions the best gainers showed more pliability and softness of skin.

USE OF A SELF-FEEDER FOR SHORT-FED STEERS.

The Illinois station reports a test of a self-feeder for short-fed steers. In general the financial results of the test were favorable for the self-feeder, and while the data are not extensive they indicate that for short feeding cattle the plan of chaffing hay, mingling it with grain, and feeding it through a self-feeder is worthy of a further investigation and trial by feeders.

SUPPLEMENTS TO PASTURE IN MISSOURI.

After five years' work in fattening cattle on pasture and supplemental feeds at the Missouri station, F. W. Mumford finds that in general the grains were more uniform and a better finish was obtained when corn was supplemented with other grain. The fatter the animal the more efficient the supplemental rations, and, hence, it was profitable to feed a limited amount of supplements containing a large percentage of protein, such as linseed meal or cottonseed meal, during the later stages of the feeding period. Although the young cattle made faster gains with nitrogenous supplements the increase was not sufficient in most cases to make it profitable.

BULKY VERSUS CONCENTRATED RATIONS.

In experiments at the Pennsylvania Experiment Station it was found that when corn was high in price it was more profitable to feed a lighter grain ration with a greater proportion of roughage, or, when a heavy grain ration was fed, to market the cattle before they became as fat as those fed heavily on grain at the close of the experiment. As in the two preceding winters, the chief demand in Pennsylvania was for cattle not made fat enough to grade as "choice" or "prime" upon the central markets, but for those that grade as "good butcher" steers or "good killers." A study of the consecutive months during the test indicated that with thin cattle a bulky ration was as efficient as one of more concentrated form, but as cattle fatten concentrates become necessary if the rate of gain is to be maintained. When corn silage was substituted for part of the ear corn the effect was to reduce the cost of production and to increase the rate of gain.

In experiments at the Nebraska station to determine the most economical proportion of corn and alfalfa, it was found that on a heavy feed of corn, and of alfalfa hay and corn stover in equal parts as a roughage, the average daily gain per head was 2.42 pounds at a cost of 6.78 cents per pound. Corresponding figures on a light feed of corn, and with alfalfa and stover in the proportions of 6:4, were 2.01 pounds at a cost of 6.51 cents. On a heavy feed of corn, and with alfalfa and stover 4.5:5.5, the gain was 2.55 pounds at a cost of 8.77 cents per pound. On a medium feed of corn, with alfalfa and stover 5.5:4.5, the gain was 2.34 pounds at a cost of 8.76 cents per pound. On a light feed of corn, with alfalfa and stover 6:4, the gain was 2.08 pounds at a cost of 8.03 cents per pound. On a heavy corn ration, with alfalfa as the only roughage, the gain was 2.73 pounds at a cost of 8.62 cents per pound, on a medium corn ration and alfalfa 2.86 pounds at a cost of 7.76 cents per pound, and on a light corn and alfalfa ration 2.71 pounds at a cost of 6.95 cents per pound. The groups fed the medium and heavy grain rations dressed practically the same, with a slight difference in favor of the medium group. Those fed the light grain ration dressed somewhat light because of their lower condition.

These experiments were made in different years and the price of feeds varied somewhat, but from the entire series it is concluded "that with corn above 35 cents per bushel and with alfalfa not to exceed $7 per ton, the old method of fattening cattle for market, namely, that of crowding with grain and using but little roughage, is much less profitable than a more moderate use of grain and correspondingly more roughage. Not to exceed three-fourths of a full feed of corn and a correspondingly larger quantity of alfalfa will give practically the same daily gains."

A TEST OF HAYS FOR WINTER FEEDING.

At the North Platte substation in western Nebraska a continuous record was kept of a mixed lot of good grade steers, which were kept in a common pasture in summer and fed different rations in winter, from December 3, 1907, to August 5, 1910. The hays tested were alfalfa, prairie, and cane. It was found that steers which went on grass in the spring thin in flesh increased in weight faster during the summer than the steers which went on grass in good flesh. The steers wintered on alfalfa or a ration of one-half alfalfa made faster gains during the winter than those wintered on prairie hay or cane alone, but did not make as fast gains the following summer. Steers wintered on a ration of alfalfa or one-half alfalfa made a greater gain during the winter and the summer following combined than steers wintered on prairie hay or cane alone. Both yearling and 2-year-old steers lost weight when fed cane or a ration of one-half cane and one-half prairie hay, whereas steers fed alfalfa or a ration of one-half alfalfa gained in weight each winter. The value of alfalfa in comparison with prairie hay or cane was higher when fed to cattle that were sold in the spring than when fed to cattle sold in the fall. At the price of feeds estimated (alfalfa $6, prairie hay $5, and corn hay $4 per ton, corn 50 cents, and oats 35 cents per bushel), it was not profitable to produce steers for the feed lot.

COST OF BEEF PRODUCTION IN THE SOUTH.

The Alabama College station, in cooperation with this department, has completed a series of experiments to determine the cost of raising a grade steer to the feed-lot period under southern conditions. The steers used were grade Angus. During the summer months no feed was given in addition to the pasture, which consisted principally of white clover, Bermuda, and Lespedeza. In addition to the winter range, hay and cottonseed were fed, the hay consisting of a mixture of sorghum, crab grass, Johnson grass, and cowpeas, and was not of good quality. For the entire year the calves made a daily gain of 0.77 pound, or a total gain of 276 pounds per head. The yearlings made a daily gain of 0.564 pound per head, or a total gain of 203 pounds for the 12 months. The cost per hundredweight of raising a steer when the manure received no credit was estimated as follows: To 12 months of age, $5.07; to 24 months of age, $4.84; to 30 months of age, $4.95; and to 33 months of age, $4.90. It is stated that these gains could have been made more cheaply if the cattle had been free from ticks, and a combination of clover and Bermuda pasture had been used to lengthen the pasture season.[1]

A FEEDING TEST IN THE NORTHWEST.

A five-year test in feeding steers at the Montana station showed a small profit except in one season. The principal feeds used were clover hay and a grain mixture of barley, oats, and wheat. With well-cured clover hay the cost of gain was about one-half of that obtained with poorly cured hay if both hays were estimated at the same price. The most economical grain ration ranged from 3 to 7 pounds, according to the quality of the hay.

PREPARATION OF CHOICE HAMS.[2]

CURING.

Home curing of hams is probably not as general as it was in former years. Still it would seem that no farmer who raises hogs should be without the knowledge required to prepare hams of good quality at least for home use. The process is comparatively simple and requires no special skill. As pointed out by E. W. Magruder, of the Virginia State department of agriculture, the essential conditions which must be realized are healthy hogs and sound meat.

> To secure the healthy hogs, give them plenty of range with as great a variety of food as possible, and plenty of good, clean water. Smithfield hogs are allowed to run at large most of the year. If you have woods to supplement your pasture, so much the better. The hogs then obtain a variety of food, as nuts, berries, roots, and grass. In hunting over the large range they take sufficient exercise to keep them healthy and develop and enlarge the muscular tissues, that is, the lean meat, but as the work is not hard, the muscles grow without becoming tough and stringy. Allow them a good range up to the time of killing, and do not fatten them in pens. They fatten as well when left out in the fields and keep healthy. As they fatten they travel less, but this travel converts much of the food into muscle or lean meat instead of altogether into fat, as is the tendency when penned, as illustrated by the western meat. To have the best meat and that which brings the best price and which has the best flavor, and with the fat and lean properly intermixed and proportioned, you must let the hogs have plenty of exercise and then kill them before they are too fat. Have them fat, but not so fat they can hardly walk. There is no economy in having them too fat, and the meat is not so good.

To secure sound meat "be careful to kill only in cold, frosty weather. After November 1 is safest. Allow to hang up all night to drain and thoroughly cool. The hog cuts out nicer and keeps better if stiff when cut out."

---

[1] For previous articles on steer feeding in the South see U. S. Dept. Agr., Farmers' Buls. 124, p. 27; 259, p. 27; 412, p. 16.

[2] Compiled from Louisiana Stas. Bul. 124, p. 56; Rpt. State Bd. Agr. Virginia, 1900, p. 114; U. S. Dept. Agr., Bur. Anim. Indus. Rpts. 1895-96, p. 97.

There are various excellent ways of curing the hams. The following, used for many years with success on the farm of Col. Chas. Schuler, commissioner of agriculture of Louisiana, is described in a bulletin of the Louisiana station:

> When hogs are fat, select any time during the month of December, January, or first half of February, when weather is clear, wind from the north to northwest, with the thermometer registering below 35° F. at sunrise. Have your water hot and scald as soon as hog is dead. Hang up and disembowel the animal just as soon as it is cleaned. No butchering animal should ever be permitted to cool off until after it is disemboweled. Cut up the carcass as soon as it is through dripping. Saw or split the backbone. Let it and the spare rib remain on the side, and make them as long as you can. Hams and shoulders small. Hams to sell readily should weigh from 15 to 18 pounds.
>
> * * *
>
> To half bushel fine salt add half pound pulverized saltpeter, 1 pound finely ground black pepper, 4 pounds brown sugar; mix thoroughly. Rub ham with mixture. Pack in box, skin side down. Apply double handful of mixture to flesh part of each ham. Then apply plenty of clean salt, never permitting the meat to touch, without salt being between, covering all parts and filling every crevice, and let them remain in the salt six weeks.
>
> After being in salt six weeks, select a clear day, string each ham, and dip in a boiling solution of 1 pound borax dissolved in 15 gallons of water and hang up high in a dark smokehouse (the higher the better) and smoke, using green hickory wood. Smoke daily for two weeks or more, as preferred. By April 1 at latest, hams should again be dipped in boiling water, to cleanse them from all impurities, wrapped in paper, then cloth, and this painted with some cheap mineral paint. Hang up again and leave until used or sold.

Two methods which have been successfully used by Virginia farmers are described by Dr. Magruder as follows:

> (1) On the fleshy surface of each ham rub in thoroughly fine saltpeter; use one tablespoonful to a 15-pound ham, and vary the amount according to size of ham. Then pack away for 4 to 6 hours, with flesh side up, in order to give the saltpeter time to strike in; then take up and rub well with salt and pack away, using plenty of salt. As they are packed away they should be pressed into plump, symmetrical shape while soft. Pack near top of bulk, and never over 2½ or 3 feet deep. If they are packed deep and have other meat put on top of them, they will be mashed flat and out of shape. They remain packed in plenty of salt for 6 weeks, when they are taken up, well washed, and when nearly dry about one teaspoonful of powdered borax is sprinkled over the fleshy surface from a large pepperbox. The borax is to keep off skippers. They are then hung up by the hock and smoked lightly on damp days with hickory chips. When about 9 months old they are sold. The hogs average about 180 pounds, making hams from 10 to 18 pounds. * * *
>
> (2) Salt lightly one or two days to bring out blood; then to each 100 pounds of hams use 8 to 10 pounds of salt, 2 ounces saltpeter, 2 pounds brown sugar, and 1 ounce of red pepper; add to 4 or 5 gallons of water in a tub and thoroughly mix. This brine should be strong enough to float a fresh egg. Place hams in a tight barrel and pour brine mixture on till hams are all covered.

After remaining in brine 4 to 6 weeks, hang up by hock and smoke gently several weeks with hickory chips. Early in March, before warm days, when flies begin to move, wrap each ham in paper and put in a bag and rehang. By late summer the hams are ready for market.

The method of preparing the famous Smithfield hams of Virginia is fully described in a report of the Bureau of Animal Industry of this department. The method of curing is there described substantially as follows:

> The flesh surface is sprinkled with fine saltpeter until the hams are as white as though covered by a moderate frost; or, say, use 3 or 4 pounds of saltpeter to 1,000 pounds of hams. Immediately salt with fine Liverpool salt, covering the entire surface. Pack the hams in bulk, not deeper than 3 feet. In ordinary weather they should remain thus for 3 days. Then break bulk and resalt with the fine salt and again pack in bulk, and each ham should remain in bulk one day for each pound the ham weighs; that is, a 10-pound ham should remain 10 days. The hams are then taken up and thoroughly cleaned by washing in warm water. When nearly dry rub the entire surface with fine black pepper. The hams should now be hung up and gradually and slowly smoked for 30 or 40 days with hickory or red oak. When the smoking is completed they should be repeppered and bagged to guard against vermin.

It is stated that "these hams improve with age, and may be considered perfect when one year old."

Commenting upon methods of curing hams, Dr. Magruder says:

> The saltpeter is used to give the ham a good, red color, to make it firm, and also as a preservative. The salt, of course, is used as a preservative, and plenty of it should be used, as the excess will not hurt, and not enough will allow the meat to spoil. When packing in bulk, be sure to press the hams into a plump, symmetrical shape, and do not have the bulk over 3 feet high, otherwise the weight will flatten out the lower hams and spoil their shape. The plumpest Berkshire ham can be spoiled in shape by improper packing. Pepper and sugar are added, presumably to improve their flavor, but I have never seen that they improve them any, and I advise against sugar or molasses, as it is more trouble and attracts flies. The pepper may be used if desired, as it will do no harm and may help to keep off skippers. The borax is added to keep off flies, which lay the eggs, which hatch into skippers, and if properly applied is a sure preventive. Bagging is for the same purpose, but unless done early and thoroughly before the flies come about it is ineffective. It is troublesome. The smoking, which should be done in damp weather, is supposed to serve several purposes. First, to dry the meat and thus make it keep better; second, to deposit a little creosote and other ingredients from the burning wood on the bacon, which improves its keeping qualities, and also supposedly improves its flavor. In my opinion, the object in curing should be to preserve the ham, keep it sound, and then let it retain all of its natural taste and flavor and not try to add flavor and taste. The natural ones, when preserved in their purity, are good enough without trying to add to them artificially.
>
> In hanging meat care should be taken not to allow any two pieces to touch, for if so they are liable to be infested with skippers. Hams should not be eaten until at least six months old. When two years old they have reached their prime. Many claim they still continue to improve for many years, but I very much doubt it.

COOKING.

As Dr. Magruder states, "after the ham is cured one of the most important operations must be gone through with before it is ready for the table—that is, the cooking."

> The hog may have been raised right, fattened properly, killed at the right time, and cured as it should be, but if it is not cooked properly the previous work is all in vain and the ham is not good. * * * A large ham—say 18 pounds—is much better flavored, sweeter, and more juicy than a small one—say under 8 pounds.
>
> Wash the ham thoroughly, then soak in cold water several hours, the time varying with the size of the ham. This soaking is to dissolve out the excess of salt. The ham is then put in the boiler full of boiling water. The temperature should then be lowered slightly and the boiler just kept simmering. Keep the water just barely boiling for 4½ hours for an 18-pound ham; that is, a quarter of an hour for each pound of ham. If the hams are larger or smaller, vary the time to suit the weight. As the water boils out, add fresh boiling water, and always keep the boiler full. For very large hams it is advisable to cook in two waters. Why should the ham be put in boiling water? Portions of the lean meat, the albumin, and some of the juices and flavors are soluble in warm water, while boiling water coagulates the albumin just as it does the white of an egg. So, if put in cold water and heated to the boiling point, some albumin and much of the delicate flavors which are so sought after in hams would be dissolved out by the water as it warmed up to the boiling point; but if put into boiling water, the albumin is coagulated at once on the surface and all the juices and flavors sealed in and kept there till eaten. While cooking the ham is just kept at the boiling point of water, which is sufficient heat to cook it thoroughly without separating the fibers or "boiling it to pieces," as a rapid or hard boiling would do.

The subject of the cooking of meats is more fully discussed in U. S. Dept. Agr., Farmers' Bulletins 34 and 391.

FACTORS AFFECTING THE PERCENTAGE OF FAT IN CREAM.[1]

One of the constant sources of friction between creameries and their patrons is the variations in the richness of cream. In order to arrive at a better knowledge of the factors affecting the percentage of fat in cream, experiments were conducted by O. F. Hunziker, of the Indiana station, and C. H. Eckles and H. S. Wayman, of the Missouri station.

In testing the effect of speed with five different makes of hand separators on richness of cream, the Missouri station found that with one exception, set for thin cream, the greater the speed of the machine the higher the percentage of fat in the cream, and this effect was much more marked when the cream screw was set for thick cream. Within ordinary limits the greater the speed the less the amount of fat remaining in the skim milk. This did not vary to any marked extent whether the separator was set for thin or thick cream. The rate of inflow was uniformly increased by the speed. The explanation given for this is not that the greater the speed of the separator the more milk will run through it in a given time, but that it is due to suction caused by the flow of air through the machine. The capacity of the separators did not vary to any extent whether set for thick or thin cream. By varying the speed of the separator the Indiana station found the cream to vary in fat content from 10 to 65.5 per cent. The work of both stations proved that, contrary to the general assumption, the higher the temperature of the milk separated the thinner the cream. This was found to be more marked when the separator was set for thick cream than for thin cream. The colder the milk separated the greater the loss of fat in the skim milk. That the percentage of fat in the cream varies practically in direct proportion with the percentage of fat in the milk separated, or, in other words, that the ratio of cream to skim milk is not changed by the variation in the richness of the milk separated, was demonstrated by both stations. Prof. Hunziker found that by varying the rate of inflow the precentage of fat in cream varied from 23.5 to 70, the greater the rate of inflow the thinner the cream. This was substantiated by Profs. Eckles and Wayman, who found that even the height of milk in the feed can affected the fat content of the cream to some extent. Acidity had but little effect according to the Missouri station, except that with sour milk there is a tendency for the percentage of fat in the cream to be increased, especially when the cream screw is set for thick cream. A small obstruction in the skim-milk tube, due to dirt or some other foreign substance, does not as a rule make any marked change in the operation of the machine. If the cream opening is partly closed, however, the cream becomes smaller in quantity and richer. The accumulation of separator slime sometimes results in a larger quantity and thinner cream due to a partial obstruction of the skim-milk tube. To show definitely the effect of the amount of water used to flush the bowl on the richness of cream, Prof. Hunziker conducted experiments with the following results. When no water was used the average percentage of fat in the cream was 37.8; with water equal in amount to the capacity of the bowl, 37.3; with sufficient water to cause the cream discharged to appear watery, 35; and when twice the amount of water needed was used the percentage of fat in the cream was 33.5.

---

[1] Compiled from Indiana Sta. Bul. 150; Missouri Sta. Bul. 94.

These experiments prove conclusively that, even though there is a wide variation from day to day in the cream tests, it does not necessarily follow that the creamery is dealing dishonestly with its patrons. They also show the necessity for uniformity in the care of milk on the farm, especially as regards separation, and in the sampling and testing of cream at the creameries.

If cream is tested correctly and if the tests of different lots of cream from the same patron vary, then these variations must be due to variations in the richness of the cream. It is impossible to procure cream of exactly the same richness from different skimmings from the gravity can. The richness of cream from a farm separator is primarily determined and regulated by the cream screw. The richer the milk the richer the cream if all conditions remain the same, for the ratio of skim milk to cream remains constant. During early summer months the milk is usually comparatively low in fat. Advance in lactation period and change from succulent to dry feed cause milk to become richer in fat. The first drawn milk is much poorer in fat than the strippings. The greater the amount of milk running into a separator of a definite capacity per hour the thinner will be the cream. The greater the speed of the separator the richer the cream. If the speed is too low a large amount of the fat is lost in the skim milk. Warm milk produces more and thinner cream than cold milk. The proper temperature to separate milk on the farm is from 90 to 95° F. and immediately after it is drawn. The more water or skim milk used to flush the bowl of the separator the thinner will be the cream. The most satisfactory cream for the creamery is that which tests about 35 to 40 per cent fat.

If the tests are to be uniform and accurate, the cream must be in such condition, when sampled, that a fair and representative sample can be taken. If, at the time of sampling, the cream is too thick, is tough, dry and leathery on the surface, is partly churned or curdy, it is very difficult to secure a fair sample, and tests of such cream are likely to be irregular as well as inaccurate.

In order that the cream may be in proper condition for sampling and testing upon delivery to creamery, the farm separator should be thoroughly cleaned and scalded after each separation; after separation, the cream should be immediately cooled and kept cool by setting in cold water; the cream should be stirred occasionally; the cream should be delivered in clean cans not less than twice per week in winter and three times per week in summer; in transit the cans should be covered with a dry blanket or jacket in winter, and with a wet blanket or jacket in summer; cans should be reasonably full of cream in transit to prevent churning.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued January 24, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

SUPERSEDED BY 954

FARMERS' BULLETIN 480.

PRACTICAL METHODS OF DISINFECTING STABLES.

BY

GEORGE W. POPE, D. V. S.,
Veterinary Inspector, Quarantine Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

U. S. DEPT. OF AGRICULTURE

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 7, 1911.

Sir: I have the honor to transmit herewith a paper on "Practical Methods of Disinfecting Stables," by Dr. George W. Pope, veterinary inspector in the Quarantine Division of this bureau, with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

19620°—Bull. 480—12

CONTENTS.

Page.
The necessity for disinfection 5
The nature of disinfection 8
Disinfectants 8
  Bichlorid of mercury 10
  Chlorid of lime 10
  Formaldehyde 10
  Carbolic acid 11
  Crude carbolic acid 11
  Cresol 11
  Compound solution of cresol 11
Details of disinfection 11
  Preparation of building 12
  Selection and preparation of the disinfectant 12
  Method of application 15

ILLUSTRATIONS.

Page.
FIG. 1. Various bacteria which produce disease in cattle 6
2. A stable with insufficient light and ventilation 7
3. A stable that is difficult and expensive to keep clean and free from the contamination of animal diseases 9
4. Pail spraying pump suitable for disinfecting small stables 12
5. A good type of barrel sprayer 13
6. A double-acting sprayer, with air chamber 14
7. A whitewashing outfit 15
8. Applying the disinfectant 16

PRACTICAL METHODS OF DISINFECTING STABLES.

In the work of the Bureau of Animal Industry in dealing with infectious diseases of live stock it has been found that the average stockman and farmer does not realize the importance of thoroughly disinfecting his premises following an outbreak of contagious disease. There is apparently a widespread lack of information regarding the germicidal power of various substances, commonly termed disinfectants. There is also a lack of knowledge concerning practical and economical methods of proceeding with the work of disinfection. Moreover, the reappearance of a contagious disease on premises from which it was believed to have been eradicated may frequently be traced to careless or imperfect work in connection with the cleaning and disinfection of the place.

This bulletin has been prepared with a view to emphasizing the importance of the thorough disinfection of contaminated buildings and to pointing out some of the most reliable disinfecting agents, together with methods of their application.

THE NECESSITY FOR DISINFECTION.

It is but natural to acknowledge the presence of only such objects as can be seen with the unaided eye. Science, however, by means of the high-power microscope, has clearly proved the existence of numerous minute animal and vegetable organisms—microorganisms—and it is a matter of common knowledge that many of these organisms frequently find their way into the animal body and produce disease. It is also well known that these microorganisms, or germs, vary in form and other characteristics and that for each disease of an infectious nature there is a specific germ.

If these germs could be confined to the animal body and die with it there would be no such thing as an infectious disease. Unfortunately, however, they are thrown off by the animal through the excretions and lie in the earth, in the litter of stables, upon the floor and walls, and in cracks and crevices. Here they may remain and maintain their virulence for an indefinite period, ready at any time to be gathered up by an animal in its feed or to be blown about in dust and drawn into the lungs.

For example, we have tuberculosis in cattle and glanders in the horse. In the former disease the causative agent is a rod-shaped

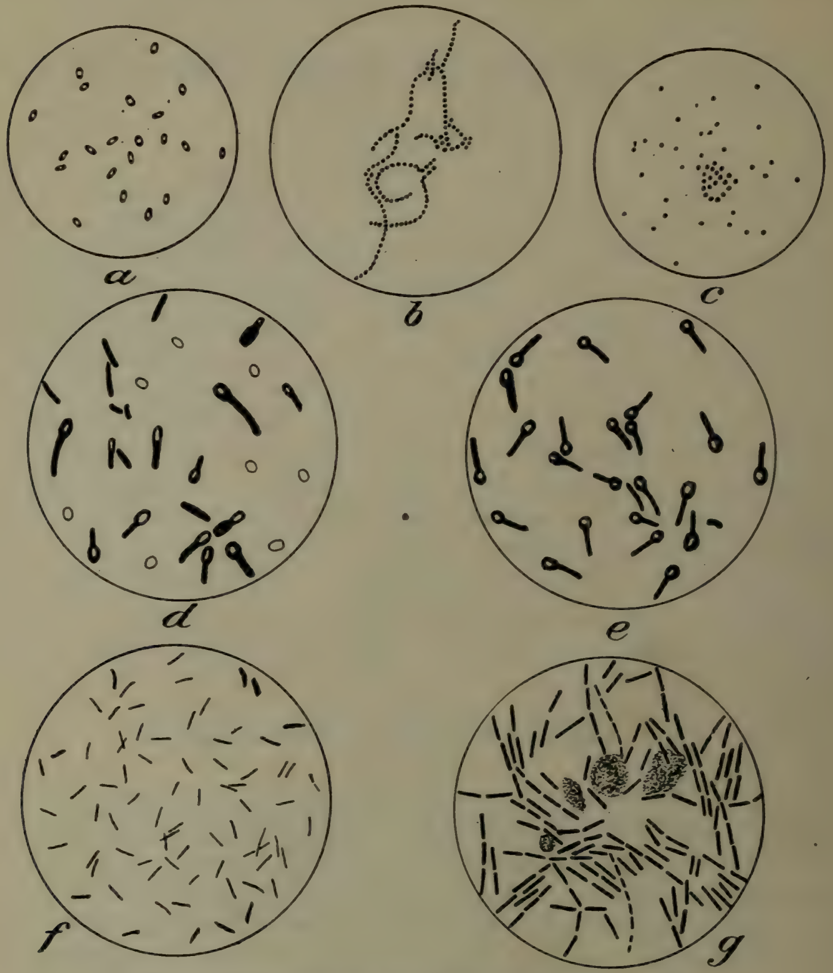


FIG. 1.—Various bacteria which produce disease in cattle.

a, Bacteria from pneumonia. These are also the cause of hemorrhagic septicemia.

b, Micrococci (streptococcus) which produce inflammation of the lining membranes of the abdomen, thorax, heart, brain, and joints. Frequently associated with the preceding bacteria in abscesses.

c, Micrococci (staphylococcus) which produce inflammation and suppuration, also pyemia.

d, Bacilli of blackleg. The oval bodies as well as the light spots in one end of the bacilli represent spores.

e, Bacilli which produce tetanus or lockjaw. The light spot in the enlarged end of each rod represents a spore.

f, Bacilli of tuberculosis.

g, Bacilli of anthrax.

(All but *g* are magnified 1,000 times; *g*, 500 times.)

germ (*Bacillus tuberculosis*), which is about one-thousandth of an inch in length. (See fig. 1, *f*.) Cattle affected with tuberculosis pass myriads of these germs with the manure. and it is not difficult to understand how in the average stable they would have little difficulty in finding many lodging places. In glanders the causative agent is another rod-shaped germ (*Bacillus mallei*), about the same length as the tuberculosis germ, but somewhat thicker. A characteristic of this disease is the formation of ulcers in the nostrils and other portions of the body, from which there is more or less discharge laden with the glanders germ. And here, again, it is not difficult to understand how one diseased animal may contaminate extensive premises.

As has been stated, some of these minute forms are vegetable organisms. In fact, these vegetable parasites are the cause of some of the most destructive diseases, and some of them are very difficult to destroy, for the reason that they contain spores. (See fig. 1, *d* and *e*.) A spore may be likened to the seed of a plant, for it bears about the same relation to the bacillus that a grain of wheat does to the plant proper. As the plant may be destroyed and the seed remain latent for an indefinite time, so destruction of the bacillus may be easily accomplished while the spores remain unharmed and retain life for weeks or months.

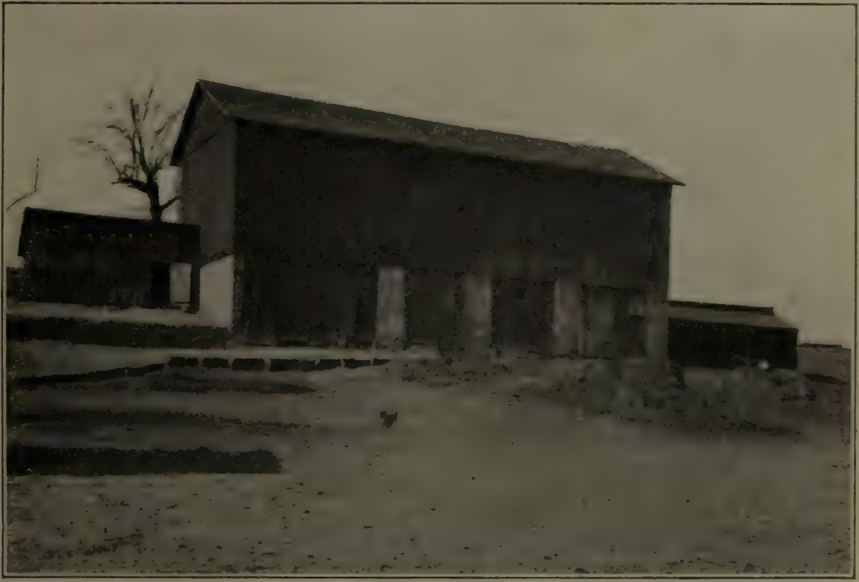


FIG. 2.—A stable with insufficient light and ventilation. Such a building is a favorable place for the existence of disease germs.

An example of this class of organisms is seen in the agent which causes anthrax (*Bacillus anthracis*). Ordinary methods for the destruction of the bacillus will not destroy the spore as well, and thus anthrax becomes a most difficult disease to eradicate. Upon farms where animals have died from anthrax and the carcasses have been buried instead of destroyed, repeated outbreaks of the disease may occur from time to time, possibly extending over a period of several years. This condition is due to the existence of the very resistant spores, which under favorable circumstances are carried to the surface of the earth and become infecting organisms—much as the seed of a noxious weed, after remaining in the soil during the winter, finds the conditions favorable in the spring and develops into a plant—except that these minute forms of life multiply with the most wonderful rapidity.

Thus it is that our increased knowledge regarding microorganisms or bacteria as the cause of many animal diseases has emphasized the importance of disinfection.

THE NATURE OF DISINFECTION.

The work of disinfection is based upon our recognition of the presence of disease germs, and disinfection means the act of destroying the cause of the infection. In other words, disinfection is a removal of the cause, and it will be clear to any practical man that in dealing with disease any effort which stops short of a complete removal of the cause is most unwise and unprofitable. To those unaccustomed to the work, disinfection may seem a most complicated process. Any approved method, however, is comparatively simple when carried out carefully, although like many another procedure it is one in which attention to details counts for much. It is important to bear in mind that the causative agents of many diseases are extremely small and may remain for an indefinite time in dust, cracks, and crevices of buildings, so that efforts aiming at the eradication of disease from contaminated premises must be thorough in order to be effective.

DISINFECTANTS.

In the work of disinfection nature has provided man with a most valuable ally—sunlight. It is well known that the direct rays of the sun are destructive to many forms of bacteria, in some cases destroying them and in others lessening their influence. Thus the importance of well-lighted stables is evident. The dark and sunless building will be a favorable breeding place for bacteria, and the structure which admits the greatest amount of sunlight will be the least favorable for their development. Again, heat will destroy the bacteria of disease. By this is not meant the ordinary heat of the sun, but heat as developed in boiling water or in flame. It is upon this principle that the surgeon before operating renders his instruments free from the possible presence of bacteria by boiling, and it is heat which renders a jet of live steam destructive to bacteria. Sunlight, however, can not be considered more than an accessory in the destruction of bacteria, while the application of heat in the form of steam or flame is seldom possible. The result is that in the practical work of disinfection we are dependent upon certain drugs, which have power to destroy the organisms of disease.

Such drugs are known as disinfectants, and, fortunately, we have at hand a number that possess the power of destroying bacteria. It is not the purpose here to consider further the relative values of these drugs, neither will it be necessary to discuss the exact manner in which they act. It is sufficient to know that they possess the power of destroying bacterial life with the same certainty that poisonous drugs destroy animal life. They have only to be brought in contact with the bacteria in order to destroy them. As disinfecting drugs vary more or less in potency and in adaptability to general use, possessing certain advantages as well as disadvantages, it may be well to describe briefly a few of the commoner forms.[1]

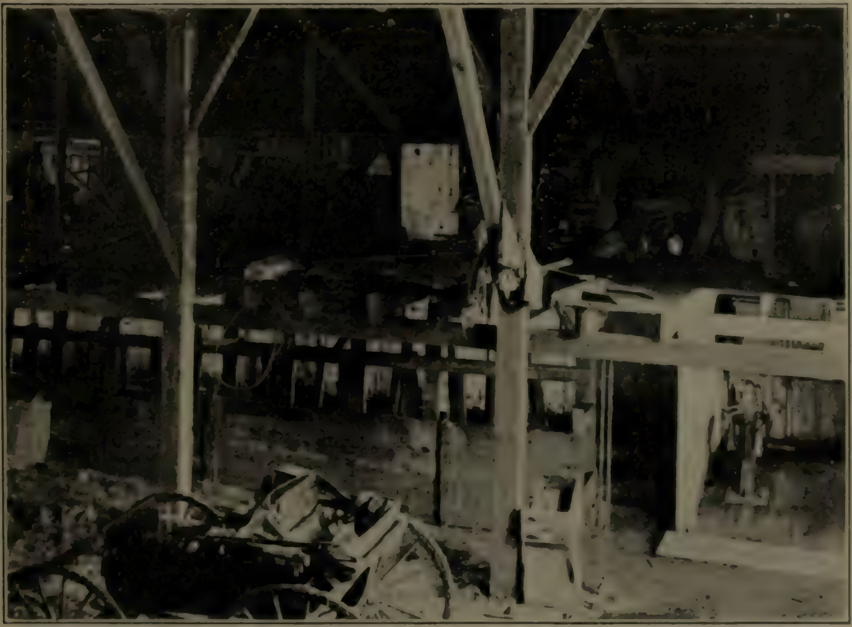


FIG. 3.—A stable that is difficult and expensive to keep clean and free from the contamination of animal diseases. Before beginning the disinfection of this stable a thorough cleaning would be essential.

---

[1] For fuller details regarding disinfecting agents the reader is referred to Farmers' Bulletin 345, U. S. Department of Agriculture, entitled "Some Common Disinfectants," by Dr. M. Dorset, chief of the Biochemic Division, Bureau of Animal Industry, from which some of the information herein given has been derived.

BICHLORID OF MERCURY.

Bichlorid of mercury, also known as corrosive sublimate and mercuric chlorid, is used in solution in water, commonly in a strength of 1 to 1,000, though solutions of double such strength may be employed. Although possessing great germicidal power, it has the disadvantages of being a violent poison, of corroding metals, and of uniting with albuminous substances, such as excreta, blood, etc., and thus forming inert compounds. Unlike the coal-tar products, it leaves no odor in the stable, which is an advantage in connection with the production of milk. On the other hand, care must be used in the handling of a solution of this drug, and feed boxes to which it has been applied should be washed with clear water before animals are again permitted access to them.

CHLORID OF LIME.

Chlorid of lime (sometimes termed chlorinated lime) is a well-known disinfectant, although its value is doubtless greatly overrated. This may be due in part to the fact that it is a powerful deodorant—such drugs on account of their pungent odor being popularly believed to have great disinfecting power. Being of uncertain strength and somewhat destructive to metals, and having a permeating odor especially objectionable in a stable where milk is produced, chlorid of lime can not be classed as the most desirable of disinfectants. For general disinfecting purposes it may be mixed with water in the proportion of 6 ounces to the gallon.

FORMALDEHYDE.

An aqueous solution containing approximately 40 per cent of formaldehyde and known as formalin has of recent years become a more or less popular disinfectant.

Formaldehyde is used in either liquid or gaseous form. In the former case formalin is mixed with water in the proportion of 6 ounces to the gallon, and the resulting solution is applied directly to surfaces or substances which are to be disinfected.

Formaldehyde gas is in most cases impracticable for stable disinfection. Where, however, a stable can be made almost air tight, and the animals removed, it will be found very serviceable, as it penetrates every crevice.

Several methods are in vogue for disinfecting with formaldehyde gas. Probably one of the most simple and practical methods of liberating such gas is by means of the chemical reaction which takes place when formalin is poured upon permanganate of potassium. For each 1,000 cubic feet of air space $16\frac{2}{3}$ ounces of crystallized or powdered permanganate of potassium is placed in a wide-surfaced pan; 20 ounces of formalin is then poured upon it, and the room immediately closed for a period of 12 hours or longer. This method is efficient only when it is possible to seal tightly the rooms or compartments to be disinfected and when their temperature is not below 50° F.

CARBOLIC ACID.

Carbolic acid in its pure form is, at ordinary temperatures, in the shape of long, white crystals. For convenience it is frequently dispensed in liquid form by the addition of 10 per cent of water. A 5 per cent solution of carbolic acid is sometimes used as a disinfectant, but carbolic acid has the disadvantage of being expensive and somewhat difficult to dissolve.

CRUDE CARBOLIC ACID.

This substance should not be confused with pure carbolic acid. It is a product of coal-tar distillation and consists for the most part of practically inert oils and cresylic acid. Its disinfecting power depends upon the amount of cresylic acid which it contains, as well as the relative percentage of hydrocarbon oils. Owing to its uncertain composition, crude carbolic acid can not be classed as one of the most desirable disinfectants.

CRESOL.

Cresol, commonly termed "straw-colored carbolic acid," "liquid carbolic acid," etc., in a 2 per cent solution is an efficient disinfectant. It has the disadvantage, however, of being somewhat difficult to dissolve, so in preparing a disinfecting solution warm water should be used and care exercised that the drug is entirely dissolved. As the disinfecting power of cresol is dependent upon the amount of cresylic acid contained therein, it is essential when using the drug to know the degree of purity. Grades can be purchased under a guaranty to contain from 90 to 98 per cent of cresylic acid. Any containing less than 90 per cent should be rejected.

COMPOUND SOLUTION OF CRESOL.

Compound solution of cresol (liquor cresolis compositus), now recognized by the United States Pharmacopeia as an official preparation, is composed of equal parts of cresol (U. S. P.) and linseed oil-potash soap. It is an efficient disinfectant in a 4 per cent solution and has the advantage of mixing readily with water.

DETAILS OF DISINFECTION.

In the practical work of disinfection there are three essentials:

1. A preparation of the building that will facilitate reaching organisms of disease.

2. A disinfectant which upon contact can be depended upon to destroy such organisms.
3. A method of applying the disinfectant that will assure the most thorough contact with the bacteria.

PREPARATION OF BUILDING.

Before beginning the use of a disinfectant it is essential that certain preliminary work be done in and about the stable that is to be treated. The various surfaces, such as ceiling, walls, partitions, floors, etc., should be swept until free from cobwebs and dust. Any accumulation of filth should be removed by scraping. In some cases the woodwork may have become softened and so porous as to be a good medium for the absorption of disease germs. Such woodwork should be removed, burned, and replaced with new material.

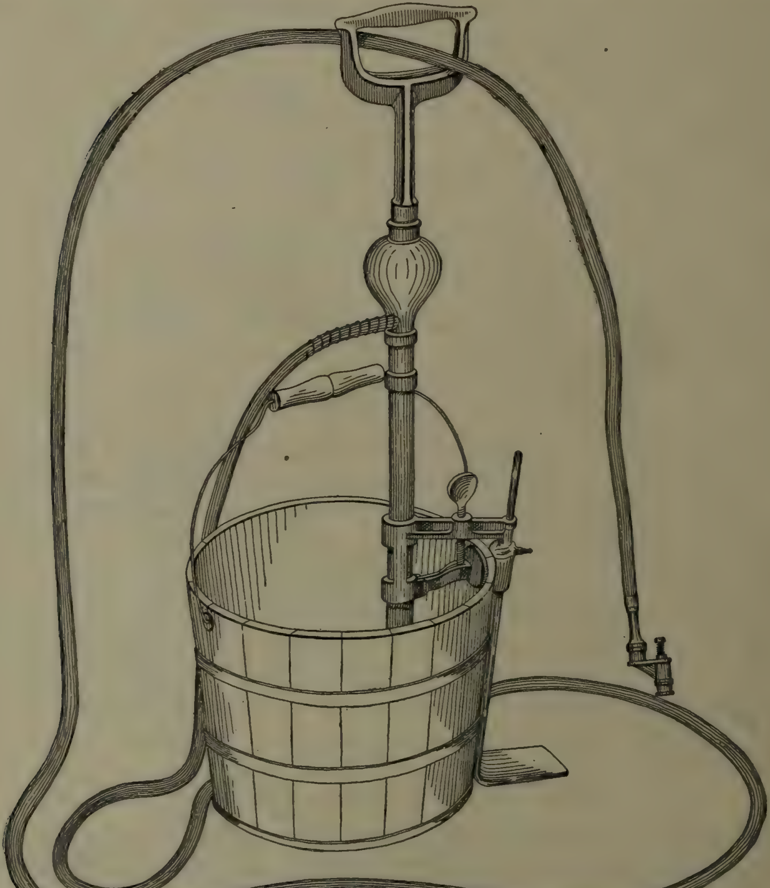


FIG. 4.—Pail spraying pump suitable for disinfecting small stables.

All refuse, manure, etc., from stable and barnyard should be removed to a place inaccessible to live stock and, if possible, be burned or thoroughly mixed with a solution of chlorid of lime in the proportion of 6 ounces to 1 gallon of water. If the floor is of earth, it will doubtless have become stained with urine and contaminated to a depth of several inches. In such cases 4 inches or more of the surface soil should be removed and treated as above suggested for refuse and excreta. All earth removed should be replaced with soil from an uncontaminated source, or better, a new floor of concrete may be laid, this being the most durable and sanitary material for the purpose.

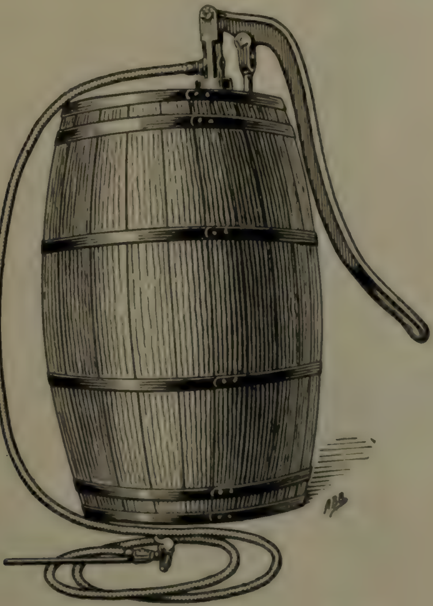


FIG. 5.—A good type of barrel sprayer.

SELECTION AND PREPARATION OF THE DISINFECTANT.

Having made ready the field of operation, the next consideration should be the selection and preparation of the disinfectant. The fact must not be overlooked that many agents used for the destruction of bacteria are likewise poisonous to animals and man. In fact, some drugs, although powerful as germicides, are so poisonous as to preclude their general use in the work of disinfection. Among such, as previously stated, is bichlorid of mercury, which possesses the power of destroying not only bacteria, but spores as well. It is therefore essential in deciding upon an agent to select one having a known germicidal strength, properties of solubility, and at the same time possessing a reasonable degree of safety to animals and man.

All things considered, it is probable that some of the coal-tar products best fulfill these requirements. In this class is the compound solution of cresol, already mentioned, a preparation recognized as official by the United States Pharmacopœia and known as liquor cresolis compositus (U. S. P.). This preparation mixes readily with water and will prove a very efficient disinfectant. It should be used in the proportion of 4 or 5 ounces to each gallon of water.

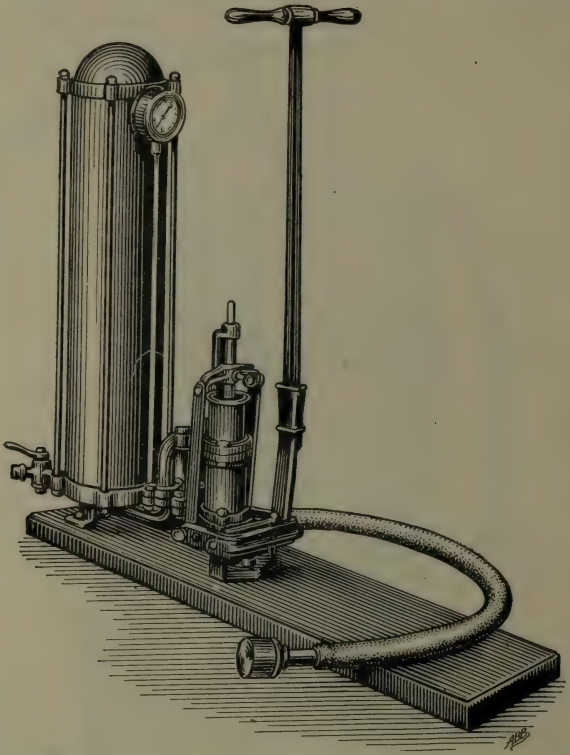


FIG. 6.—A double-acting sprayer, with air chamber.

Another favorable agent is cresol (commercially known as liquid carbolic acid). It is not as soluble as liquor cresolis compositus and should be thoroughly stirred during the process of mixing, which will be facilitated by using hot water. It is advisable to secure a grade of the drug with a guaranty of 95 per cent pure, and such should be used in the proportion of 2 or 3 ounces to a gallon of water.

As an accessory preparation and for use after the application of the disinfectant it may be advisable to make ready a lime wash to each gallon of which there has been added 4 ounces of chlorid of lime, or if it appears desirable to use the disinfectant and lime wash at one application, the following method may be followed in preparing 5 gallons: Slake 7½ pounds of lime, using hot water if necessary to start action. Mix to a creamy consistency with water. Stir in 15 fluid ounces of cresol (commercially known as liquid carbolic acid) at least 95 per cent pure, and make up to 5 gallons by adding water. In case compound solution of cresol (liquor cresolis compositus) is used, add 30 fluid ounces instead of 15 as in the case of cresol (liquid carbolic acid). Stir thoroughly. If to be applied through a spray nozzle, strain through a wire sieve. Stir frequently when applying and keep covered when not in use.

In case a large surface is to be disinfected it will be advisable to prepare a liberal amount of the disinfecting solution before beginning the application. Such solutions, however, should not be permitted to remain in receptacles which are accessible to animals.

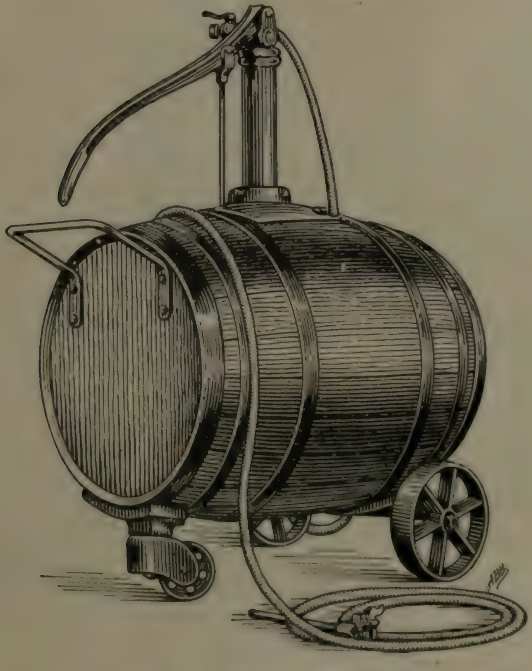


FIG. 7.—A whitewashing outfit.

METHOD OF APPLICATION.

The efficacy and economy of the work will depend in a great measure upon the method of applying the disinfectant. Economy requires that the disinfecting solution be applied rapidly; efficiency requires that it be not only spread in such manner as to cover the entire surface requiring disinfection, but that sufficient quantity and force be used to drive the solution into all cracks and crevices.

Where a very limited surface is to be treated, as, for example, one stall, it may be possible to apply the disinfectant in a satisfactory manner by means of a whitewash brush. In all cases, however, the best method of applying the disinfectant and the lime wash is by means of a strong spray pump. Such should be equipped with not less than 15 feet of hose, to which may be attached a 5-foot section of iron pipe of the same caliber. With a spraying nozzle at the end of the pipe the operator will be enabled to proceed with the greatest possible dispatch and the least possible inconvenience.

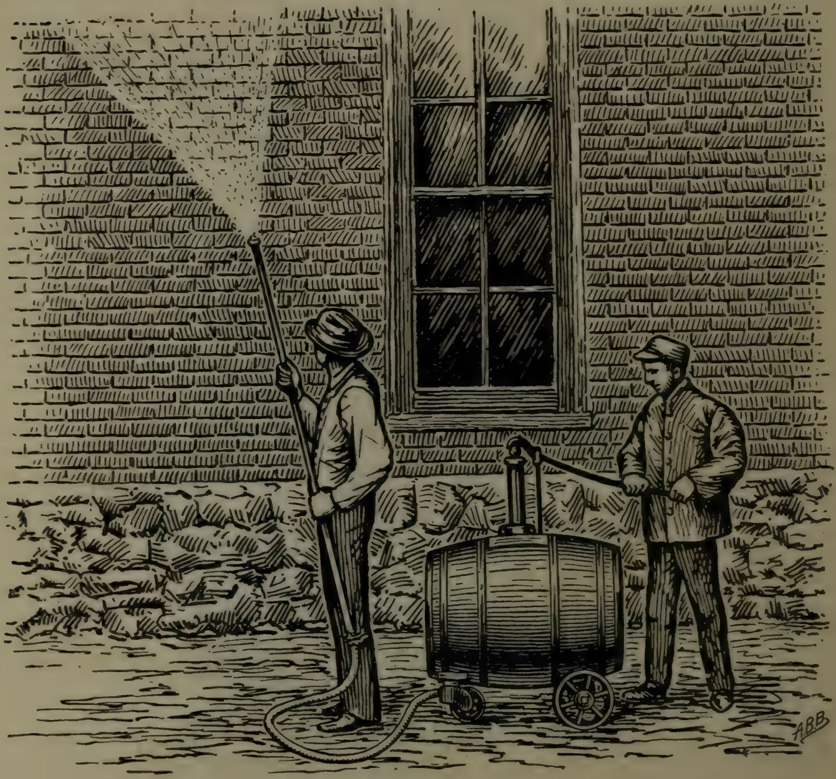


FIG. 8.—Applying the disinfectant.

The entire interior of the stable should be saturated with the disinfectant. Special attention should be given to the feeding troughs and drains. After this has dried the surface may be sprayed with lime wash, provided this has not been combined with the disinfectant as described on page 15; and when this process has been completed it will be advisable to open all doors and windows of the building for the admission of air and light.

Issued March 18, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 481.

CONCRETE CONSTRUCTION ON THE LIVE-STOCK FARM.

PREPARED UNDER THE DIRECTION OF THE
BUREAU OF ANIMAL INDUSTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

U. S. SUPT. OF DOCUMENTS.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 23, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "Concrete Construction on the Live-Stock Farm," which I respectfully recommend for publication as a Farmers' Bulletin. Concrete is being used on farms to an increasing extent and has been found well adapted for certain purposes on stock farms. The accompanying paper deals especially with the construction of feeding floors, manure pits and basins, and dipping vats. The reader desiring further information is referred to Farmers' Bulletin 461, "The Use of Concrete on the Farm," prepared under the direction of the Office of Public Roads of this department.

Respectfully,
A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction........ 5

Requirements of a good feeding floor........ 6

The advantages of concrete floors........ 6

How to build concrete feeding floors........ 7

- The selection of the materials........ 7
- Choosing the location of the floor........ 8
- The drainage foundation........ 9
- The tools and equipment necessary........ 9
- The proportioning and mixing of the concrete........ 9
- General method of grading or sloping floors........ 10
- General method of construction........ 14
- Curing the floor........ 17
- Feeding floors for cattle........ 18
- Feeding floors for hogs........ 18
- Feeding floors for sheep........ 20
- Feeding floors and swimming pools for poultry........ 20
- The cost of concrete floors........ 20

Concrete manure pits........ 21

- Ordinary methods of storage wasteful........ 21
- Shallow manure pits........ 21
- Manure basins........ 23

Concrete dipping vats........ 26

- Draining pens........ 30
- Dimensions of ground pits for dipping vats........ 32
- Care of concrete dipping vats........ 32

ILLUSTRATIONS.

Page.

Fig. 1. A good feeding floor 6
2. The proper way to store cement 8
3. Tools used in making concrete on the farm 10
4. Measuring box 11
5. Grading the floor 12
6. Forms for a feeding floor 13
7. Failure of a feeding floor on account of hog wallows 15
8. Feeding floor, showing trough to manure pit 16
9. A good cattle feeding floor 17
10. Cattle and hog feeding floor 18
11. A good hog feeding floor 19
12. Feeding trough for hogs 20
13. Concrete swimming pool for ducks and geese 21
14. Old-fashioned method of storing manure 22
15. A concrete manure pit, by which all the manure may be saved 23
16. Manure pit forms 24
17. Manure pit with trough 24
18. Shallow manure pit 25
19. Section of shallow manure pit 25
20. Drawing of a manure pit for the Morgan Horse Farm, Middlebury, Vt. 26
21. Concrete horse and cattle dipping vat 27
22. The same vat; view in opposite direction 28
23. The same vat, showing double draining pens and arrangement of gates. 29
24. Details of construction of a dipping vat 31

CONCRETE CONSTRUCTION ON THE LIVE-STOCK FARM.

INTRODUCTION.

Some of the increased cost of living may be traced directly to the decreased producing power of the farm lands. This condition has been largely brought about by delivering the harvested crop direct to the market and returning nothing to the fields. The problem of restoring the soil to its former fertility, together with the advanced price of meats, makes it highly profitable for every farmer to raise a certain amount of live stock. The manure thus produced, properly cared for and distributed, returns to the cultivated land a large part of the fertility which the crop of grain removed. From the sale of his live stock the farmer realizes a direct profit on his grain consumed, and also, through the use of the manure, increases the fertility of his fields.

During the period of cheap lands and grains, animals were generally allowed to run at large and were fed for the market only when they happened to be large enough. Feeding consisted in hauling out the feed and dumping it down in what seemed the least muddy spot on that particular morning. This method, as compared with feeding on the bare ground in lots, had this merit: Whatever the stock did not eat, together with the droppings, was scattered over the pasture instead of being allowed to pile up and to leach or wash away with the heavy rains. However, from the present standpoint of high-priced lands and grain, such methods of feeding are too wasteful. The feed becomes mixed with mud and is not so good for the animal. By tramping and rooting for fragments the next season's growth of grass is damaged by the animals and weeds are given an opening. In addition, the stalks, husks, cobs, and other manure from feeding should be returned to the cultivated fields which are in immediate need of fertilizing material.

REQUIREMENTS OF A GOOD FEEDING FLOOR.

The value of the feeding floor was long ago recognized. The difficulty has been to obtain a floor that would possess all of the necessary qualities without any accompanying disadvantages.

Such a floor must save the fragments of feed dropped upon its surface and keep them clean, so that such particles may be eaten by some animal.

It must be capable of being easily cleaned and disinfected, so that it may never become dangerous to the health of the animal feeding from it.

Its surface must be such that none of the manure deposited on it will be absorbed and that all of it may be easily removed for storage.

The cost of the floor must be moderate.

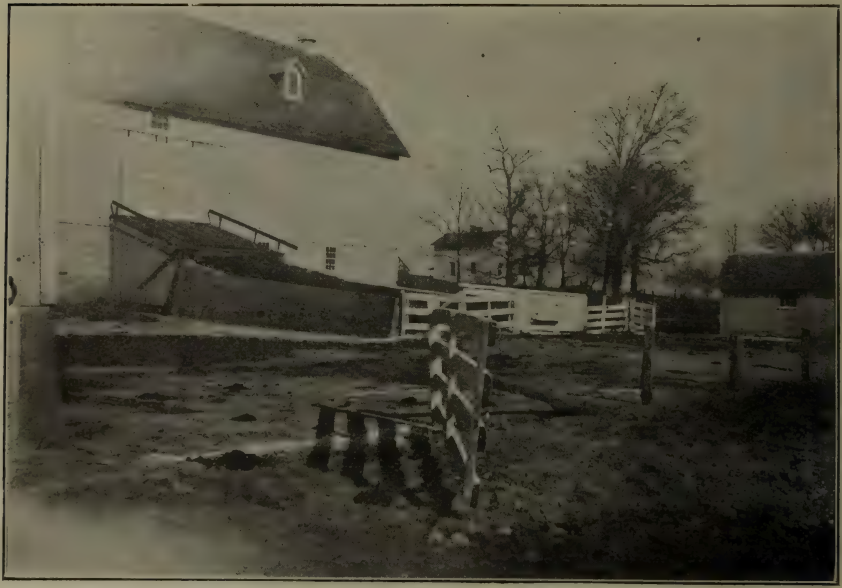


FIG. 1.—A good feeding floor.

THE ADVANTAGES OF CONCRETE FLOORS.

As a building material concrete is most valuable for floor construction.

Concrete floors are moderate in first cost; they last forever. All of the manure deposited upon them is easily removed for storage.

Their surface is such that they can be cleaned and disinfected with ease. Through their use the farm is freed of foul, muddy barn lots, the breeding place of disease—spreading gnats, flies, and mosquitoes. Likewise, rats and other destructive animals can find no home about concrete floors.

The saving of grain, of labor, and of manure is so great to the feeder that concrete floors may pay for themselves in the short space of one year.

With the use of concrete floors the general appearance of the farm is improved, the disagreeableness of wading through mud and mire is obviated, and farm life in general is made more attractive.

HOW TO BUILD CONCRETE FEEDING FLOORS.

THE SELECTION OF THE MATERIALS.

Sand for concrete should be clean and should have grains grading in size from fine to coarse. Such material as drift sand, with all fine, light grains, makes very weak concrete. Sand which will considerably discolor the hands when a portion is rubbed between the palms should not be used unless well washed. With dirty sand no amount of cement will make strong concrete.

Bank-run gravel, just as dug from the pit or taken from the stream bed, seldom runs even and rarely has the right proportion of sand and pebbles for making the best concrete. The mixture most suitable has one part sand to two parts gravel, measured by volume, in which all sizes passing through a quarter-inch screen are considered sand. As there is generally too much sand for the gravel, it is advisable to separate[1] the sand from the gravel and later to remix them in the proper proportion. For concrete feeding floors no pebbles larger than 1 inch should be used. The larger stones will do for the foundation. Gravel should have no rotten stone and should be clean, that the cement may adhere to it tightly.

The best stone for crushed rock is one which is clean, hard, breaks with sharp angles, and to which mortar easily sticks. Trap, granite, and hard limestone are among the best. The use of shale, slate, and very soft limestones and sandstones should be avoided. The crushed rock should be screened only enough to remove the very fine dust. The small particles should be left in the stone and allowance made for them in proportioning the amount of sand.

On account of its cheapness, uniformity, and quick development of strength, Portland cement is practically the only kind now used. Many brands of Portland cement are on the market, from which the farmer should select some well-known make, guaranteed by the local dealer to meet the standard specifications for cement of the United States Government, to be obtained from the United States Bureau of Standards, Washington, D. C.

Cement takes up water so easily that it must never be stored on the ground or be exposed to driving rains or moisture-laden drafts of air. Figure 2 shows a very good method of storing cement. Within a building, place blocks or timbers close together upon the regular floor and upon these timbers lay a loose floor. (Remember that, though small, a sack of cement is heavy. Do not pile it too high, and never against the walls of buildings.) Pile the cement upon the raised floor and keep it covered with canvas or roofing paper. Cement once wet sets up and is unfit for use. However, lumps caused by pressure in the storehouse must not be mistaken for set-up cement. Such lumps are easily crumbled.

---

[1] Because cement is cheap, many farmers prefer to use a little more cement and not to screen the gravel. However, by screening they will obtain a stronger concrete and at the same time make a saving in cement more than equal to the cost of screening.

Any good-tasting drinking water is suitable for concrete.

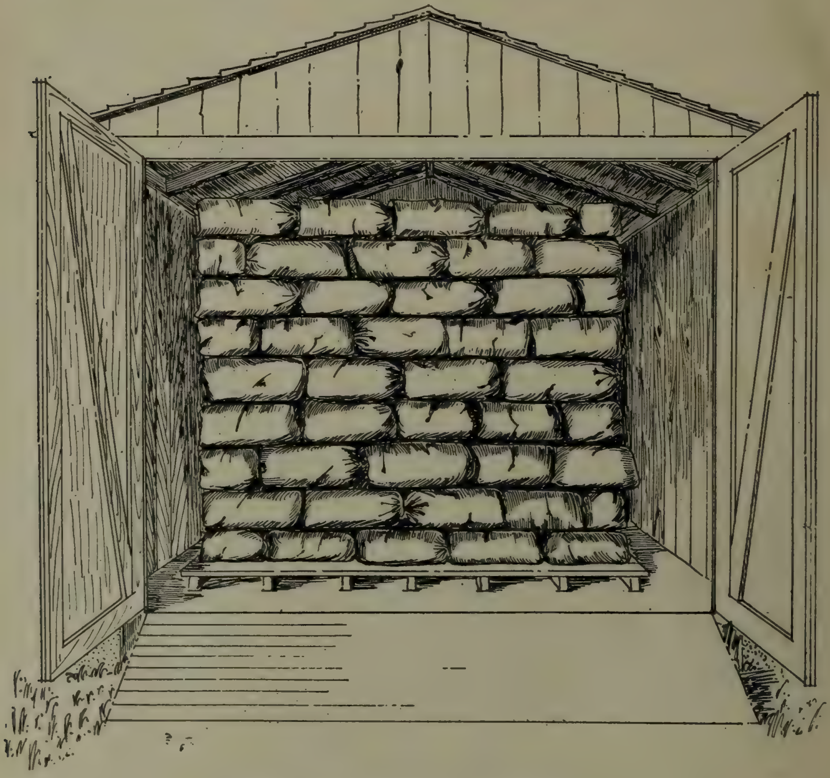


FIG. 2.—The proper way to store cement.

CHOOSING THE LOCATION OF THE FLOOR.

In choosing the site for a feeding floor, consider the following points:

(1) The natural drainage of the ground, due to its gentle slope.
(2) The convenience with regard to the feed supply.
(3) The nearness to the animal sheds, barns, or houses.
(4) The means for watering the stock upon the floor.
(5) The protection from winter winds afforded the site by surrounding buildings, wind walls, or fences.

Having chosen the location of the floor, haul the materials (slightly more than the actual amount required) at odd times and pile so as—

(1) To make the least work in wheeling to the floor.

(2) To be on the side most convenient to the water supply for mixing.

(3) To allow room for the future location of the mixing board.

THE DRAINAGE FOUNDATION.

Where the ground never freezes, drainage foundations are entirely unnecessary. If the location of the floor is poorly drained it is a wise precaution to remove the earth to a depth not less than 4 inches and to tamp in its place a fill of coarse gravel, crushed rock, broken tile, or brickbats. This will prevent upheaval by frost and consequent cracking of the floor. By this arrangement the floor will be its own thickness above the surrounding ground, which is a desirable feature.

THE TOOLS AND EQUIPMENT NECESSARY.

All of the tools and equipment necessary for making a concrete feeding floor are already at hand on most farms or will be useful afterwards for other things. Following is a list:

2 square pointed "paddy" shovels No. 3.
1 round pointed tiling shovel or 1 garden spade.
1 heavy garden rake.
1 sprinkling can or bucket, or 1 spray nozzle for hose.
1 water barrel or a length of hose.
1 sidewalk tamper or homemade wooden tamper.
1 wooden float (a homemade wooden trowel).
1 sand screen made of a section of ¼-inch wire mesh nailed to a wooden frame.
1 measuring box or frame. (See "Proportioning and mixing," below.)
1 mixing board. (See "Proportioning and mixing," below.)
Lengths of 2-inch lumber for forms for floor.
2 wheelbarrows. (Steel trays are better than wooden.)

THE PROPORTIONING AND MIXING OF THE CONCRETE.

A fairly rich mixture makes the best concrete floors. Mix bank-run gravel 1 to 5—that is, 1 part of Portland cement to 5 parts of gravel by actual measurements.[1] With screened gravel or crushed rock the materials should be mixed 1 to 2½ to 5—that is, 1 part Portland cement to 2½ parts screened sand to 5 parts screened gravel or crushed rock. While doing concrete work in hot weather the pile of crushed rock should be kept thoroughly wet.

In measuring the quantities, splitting of bags of cement may be avoided by bearing in mind the fact that a sack of cement (emptied loosely) practically fills a box holding 1 cubic foot. Therefore make all measurements of sand, gravel, and crushed rock in even cubic feet. Gauge the wheelbarrows by using a bottomless box holding 1 cubic foot, or construct a shallow bottomless frame which, when set on the mixing board and filled, will contain the *full* amount of sand or *one-half* the quantity of gravel or crushed rock required for one batch of concrete.

---

[1] Measurement by counting shovelfuls is poor and uncertain practice. Be exact.

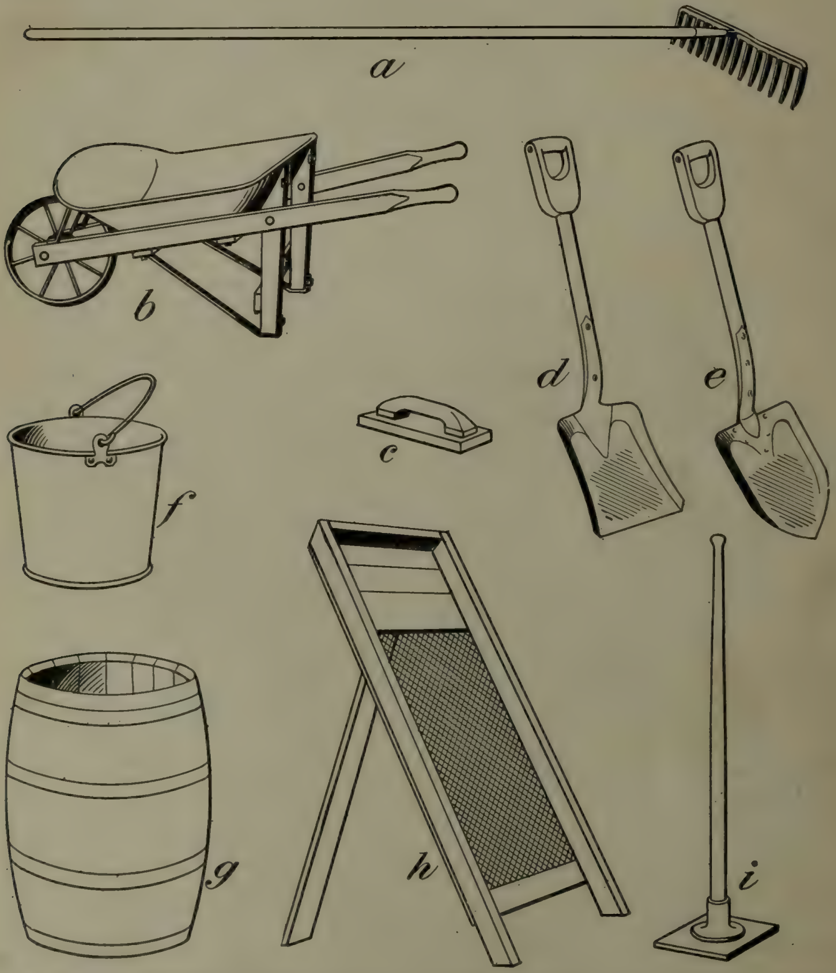


FIG. 3.—Tools used in making concrete on the farm: *a*, Rake; *b*, wheelbarrow; *c*, wooden float; *d*, square nosed shovel; *e*, round-nosed shovel; *f*, bucket; *g*, water barrel; *h*, gravel screen; *i*, tamper.

The size of the batch is dependent upon the number of men working and the dimensions of the mixing board or platform. For ordinary jobs sufficient room will be had on a "two-men board," 8 by 14 feet, framed solidly and built of matched one-inch stuff, with tight joints the short way of the board. Nail a wooden strip around the outside edge to prevent the loss of liquid cement. For such a platform and a proportion of 1 to 5 or 1 to 2½ to 5 (see p. 9) use a measuring box of 1-inch stuff, 6 inches deep, 2½ feet wide, and 6 feet long. All measurements in the clear.

If the gravel does not need screening (see "The selection of materials," p. 7) place the bottomless frame, described above, on the mixing board and fill it level full with bank-run gravel. Lift the frame, spread the gravel slightly with a garden rake, and upon it distribute evenly three bags of cement, the full amount. Set the frame upon the leveled surface of the cement and gravel and again fill it with gravel. Remove the frame and level down the entire mass by dragging it back and forth with the rake. Two men opposite each other then turn the batch with No. 3 square pointed "paddy" shovels. Again use the garden rake and keep turning until the cement no longer shows in streaks. Throw up the frazzled edges and, with a sprinkling can or a hose with a spray nozzle, apply all the water the mixture will take up. Turn again and add a smaller amount of water. (The concrete should be sufficiently wet that when tamped into place a little liquid cement will come to the surface.) With wheelbarrows quickly remove the concrete to the site of the work and put it in place.

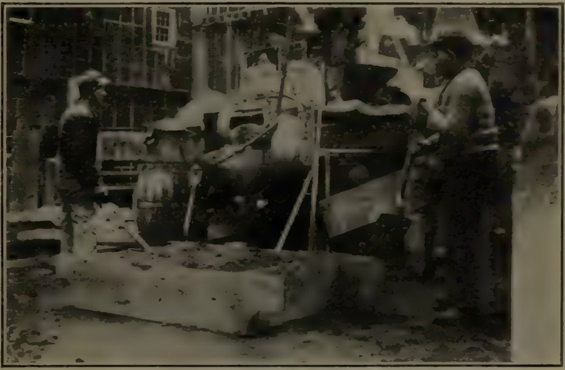


FIG. 4.—Measuring box.

If crushed rock or screened gravel is to be used fill the bottomless frame with sand and distribute upon it three bags of cement. Drag the materials back and forth with a garden rake, then turn in the manner described above until the mass has a uniform color. Apply water in a similar way. Spread out the wet mixture of sand and cement so that two framefuls of screened gravel or crushed rock may be placed upon it. Wet the mass and turn as for bank-run gravel until each stone is coated with cement mortar. Quickly remove the concrete to the work with wheelbarrows and place it.

GENERAL METHOD OF GRADING OR SLOPING FLOORS.

The floor must be graded or sloped, so that water will not collect and freeze on it in winter and so that the manure washings may be caught and run, by means of gutters made in the floor, to the water-tight concrete manure pit. To illustrate a method of grading which

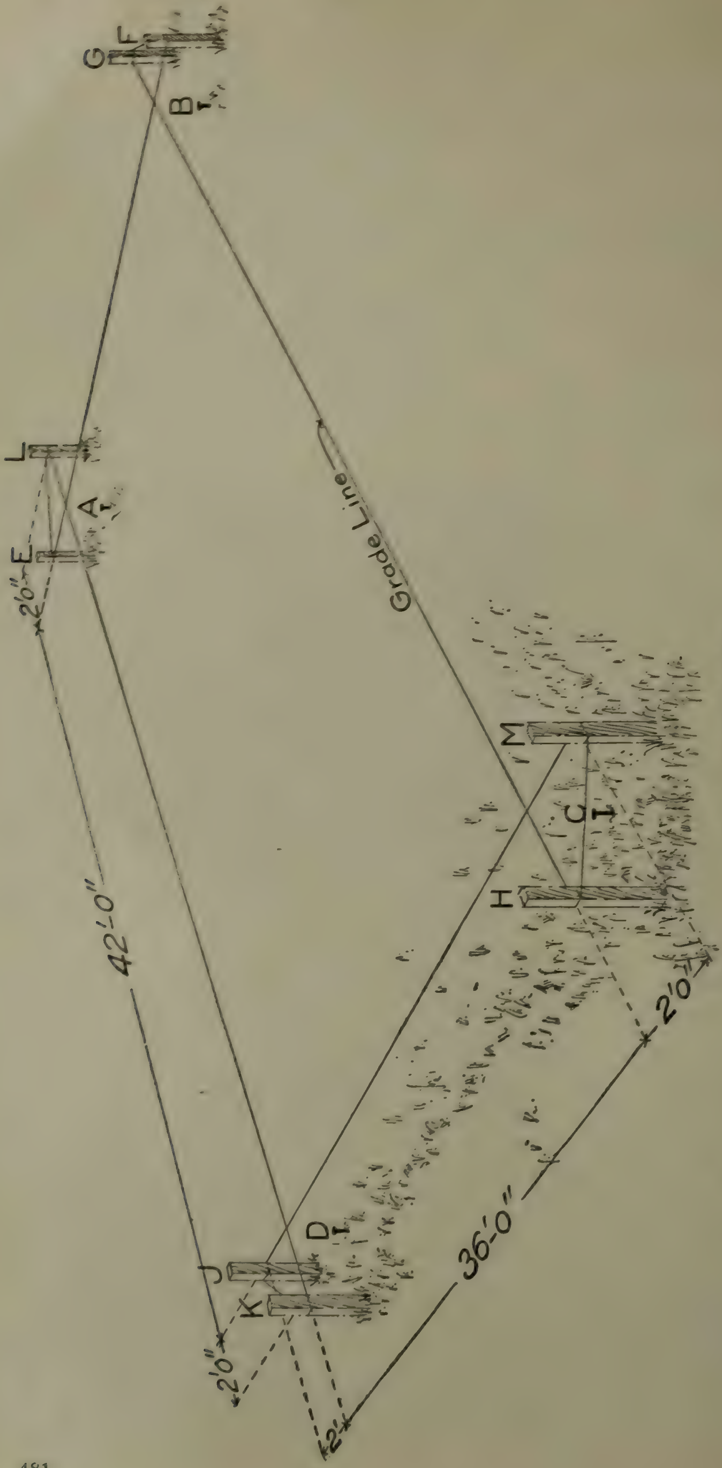


FIG. 5.—Grading the floor.

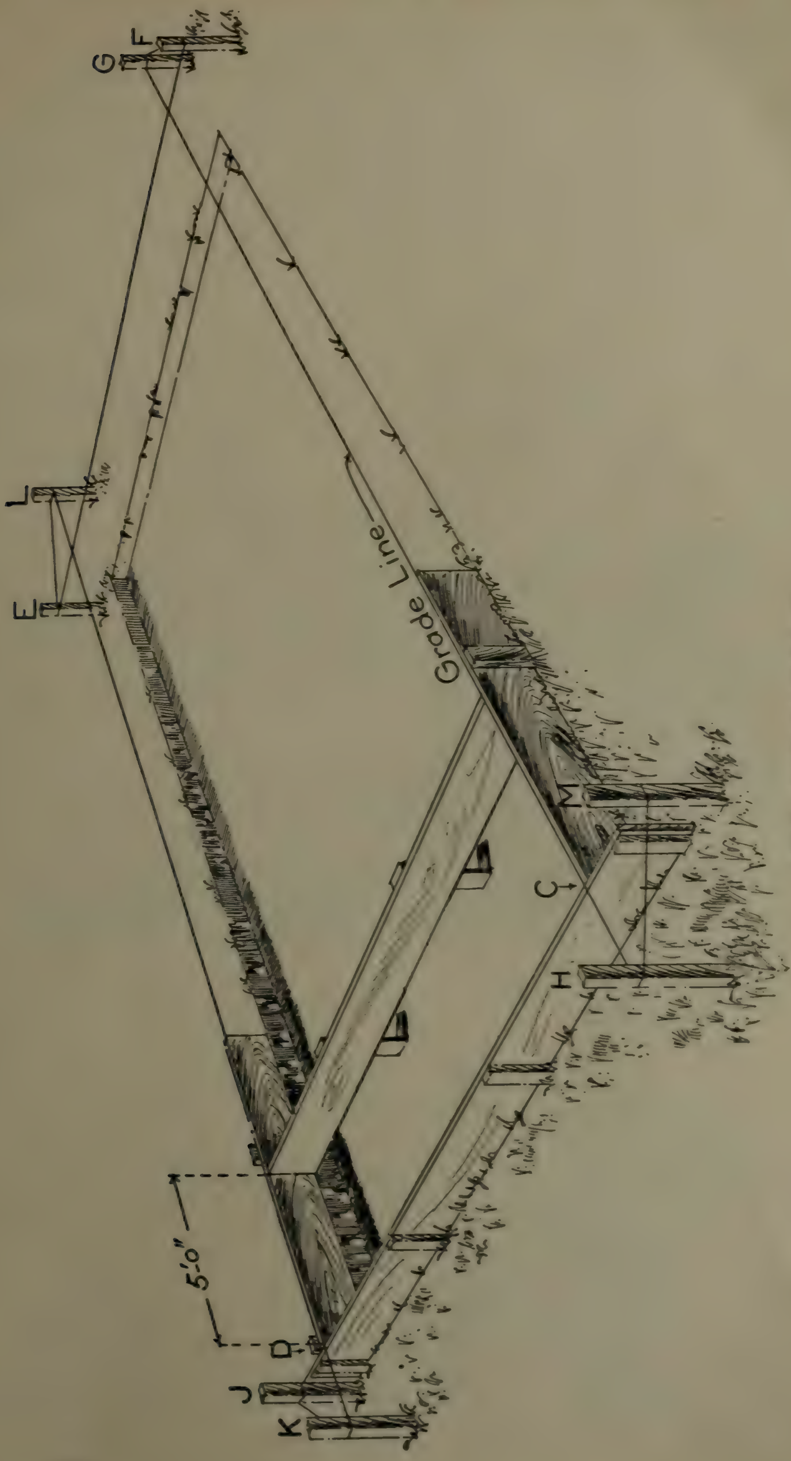


FIG. 6.—Forms for a feeding floor.

can be applied in general to all floors the following description is given for a feeding floor 36 by 42 feet:

Lay out the floor and mark each corner by driving a spike nail into the ground. To preserve the lines while working, stretch a string over the nails marking two sides—say *A B* (see fig. 5)—and drive stakes *E* and *F* with their faces to line exactly 2 feet beyond the corners of the floor. Likewise locate and drive stakes *G* and *H*, *M* and *J*, *K* and *L*. These stakes must be long enough to be driven firmly into the ground and to extend 12 to 15 inches above it. On stake *E* cut a notch 5 inches above ground level. By means of a straight edge or a tight chalk line, together with a carpenter's level, on *F* find a point level with the grade notch on *E*. Since the floor should have a slope of one-eighth inch per foot (for purposes of drainage) and the distance between *E* and *F* is 2 + 36 + 2 = 40 feet, cut the grade notch on *F* forty eighths or 5 inches below the level mark. From the *grade notch* on *F* run a level line to *M*. The distance is 42 feet, therefore the grade notch is forty-two eighths or 5¼ inches below the level line. Returning to the grade notch on *E* run a level line to *J* and cut the grade notch forty-two eighths or 5¼ inches below the level line. Beginning at the grade notch on *E* stretch the chalk line to the grade notch on *F*, around *F* to *G*, around *G* to *H*, around *H* to the grade notch on *M*, from *M* over the line *G H* to the grade notch on *J*, around *J* to *K*, and around *K* to *L*. Raise and lower the line *K L* until it barely touches the lines *E F* and *J M* at points *D* and *A*. Do likewise to *H G* with reference to the points *C* and B. Thus adjusted the lines show the grade of the top of the finished floor.

GENERAL METHOD OF CONSTRUCTION.

The methods of constructing the several kinds of concrete feeding floors are so similar that, in general, they can be explained under one head. Special features of each kind of feeding floor will be discussed under separate topics. So many local conditions enter into the placing of watering tanks, feeding troughs, and dipping tanks and vats that little advice can be given on their location with respect to the floor other than that such things through their length usually govern the direction in which the floor will be laid in sections. Provision must be made for intake, overflow, and drain pipes for these tanks *before* the floor is laid.

With the grade line established by means of the string, as shown in figure 5, set the forms of 2 by 6 inch dressed lumber (or of whatever width the thickness of the floor calls for) along one of the *lower* sides (*D C* or *C B*), say *D C*. Let the forms project beyond *D* and *C*, as shown in figure 6, and nail them to heavy stakes driven solidly into the ground, so that the inside of each board at the top edge barely touches the grade line. Two inches back of both *C* and *D* nail a cleat or block on the inside of the form along *D C*. Dig a trench 8 inches wide and 18 inches deep along the form *D C* on the inside and continue the same around the corners and 7 feet beyond in the direction of *A* and *B*. (This trench filled with concrete serves as an apron to keep out rats or water and to prevent undermining of the floor by hog wallows.) In the same way as the forms for *D C* were placed, set two shorter boards (say 12 feet long) to grade, one extending from *D* toward *A* and the other from *C* toward *B*. From points on top of these boards, 5 feet from *D* and *C*, stretch a cord, and then set the inside form to this temporary grade line.

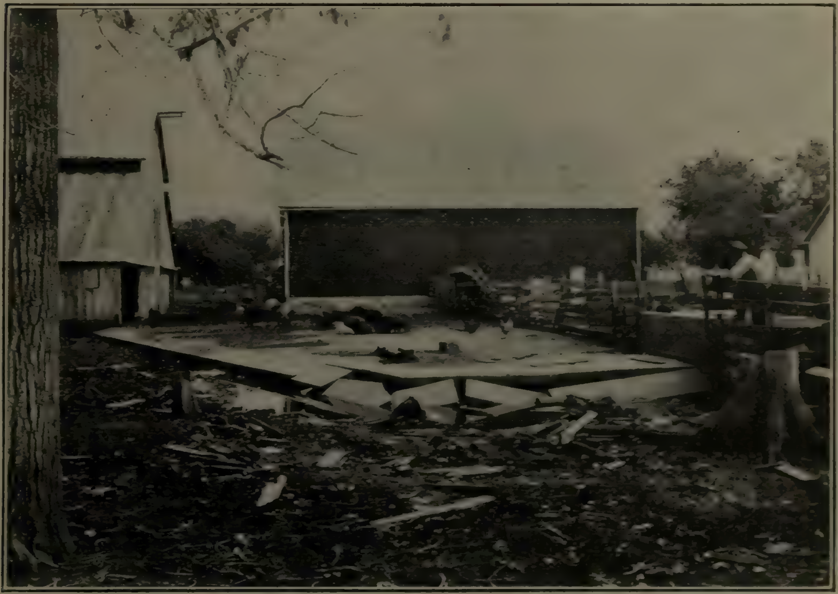


FIG. 7.—Failure of a feeding floor on account of hog wallows. The floor should have had a lip turned down into the ground to prevent hogs from wallowing under it. However, note the value of jointing; the floor broke straight and can be repaired.

With the forms in place and all things ready, mix the concrete as directed under "The proportioning and mixing," page 9.

Always begin placing the concrete at the lower end of the section (in this case at *C*), so that rain from sudden showers will not run from the hard onto the newly placed concrete. Likewise, the set-up, finished floor may be sprinkled without water running upon the unfinished concrete. Fill the trench for the concrete apron as the floor is built. Without striking the forms, dump the wheelbarrows into the section and shift the concrete where needed with a tiling shovel or a garden spade. In tamping the concrete next to the forms or to the edge of a green section lay down a short, narrow board and strike it with the tamper. A wooden straightedge extending from form to form will show when the section is at the right height. Smooth down the concrete with a wooden float—a 1 by 6 by 10 inch homemade trowel. No finishing mortar is needed for the top. When a portion of the floor has set sufficiently for the liquid cement to disappear, roughen the surface by brushing it lightly with a stiff broom, such as a barn broom or paving brush. With a trowel or a sidewalk edger bevel or round the outside edges of the floor.

As soon as one section is completed, if the concrete at the end first placed is hard enough to bear considerable pressure from the thumb, remove that part of the inside form, set it up to grade 5 feet distant, and proceed laying the second section. In tamping and in using the straightedge do not damage the adjoining floor. It sometimes happens that the first section when completed is too soft for any part of the forms to be taken down. In that case wait a half hour until the concrete has become hard, or leave out the second section and proceed to lay the third.

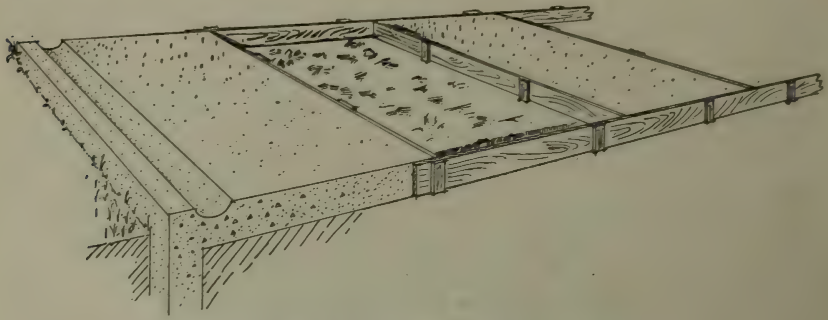


FIG. 8.—Feeding floor, showing trough to manure pit.

If tanks or troughs are to be made upon the floor and with the floor as the bottom of the tank, have the forms ready. To be watertight, such things must be built as one piece and at one time. Around the outside of the tanks, the same as for buildings, there should be built an 8-inch foundation wall extending 3 feet into the ground. A width of heavy woven wire in the concrete bottom (the floor) 1 inch from the under side and projecting up into the side walls will prevent cracks caused by faulty drainage foundations. The side walls of tanks should be well reinforced, 1 to 2 inches from the outside, with steel rods or heavy woven wire. To resist ice pressure, these walls should be heavier at the bottom than at the top, with the sloping face on the inside of the tank. For all tanks mix the concrete 1 to 2 to 4, according to the directions under "Shallow manure pits," page 21.

To insure getting the liquid manure into the pit, mold a gutter in the floor along its two lower sides, such as is shown in figure 8. To shape the gutter, make a mold or templet by rounding the corners of the flat side of a 4 by 6 inch timber. Four inches in from the edge, on each of the lower sides, temporarily embed this rounded 4 by 6 inch gutter mold and tamp it down until its square top is even with the surface of the floor. Let the water enter the manure pit at the junction of these gutters. Use some arrangement, such as the trough in figure 8, for carrying off surplus rain water not needed in the manure pit.

Should the work be interrupted, even for the noon period, place a board crosswise of the section similar to an inside form, and thus bring the concrete to an abrupt end.

Do not mix concrete until it can be used at once. Concrete which has been mixed for 30 minutes is unfit for use even though remixed or retempered with fresh cement and water.

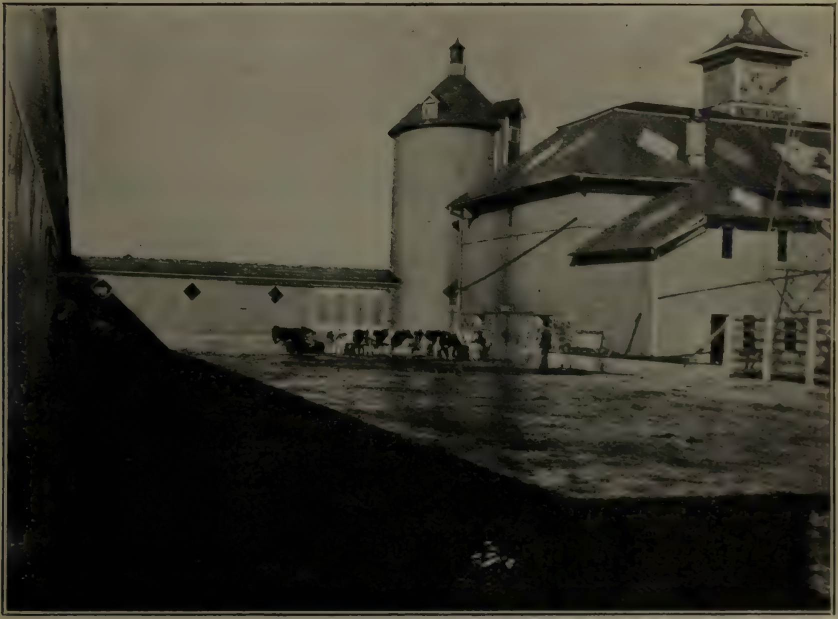


FIG. 9.—A good cattle feeding floor.

Concrete work may be carried on during freezing weather by heating the water or the sand and the stone. However, it is advisable not to attempt work when the thermometer registers 32° F. or lower. Often, when the temperature is above this point, concrete is frozen and ruined because frosty gravel from a frozen pit is used.

CURING THE FLOOR.

Proper curing of the floor is as important as thorough mixing of the concrete. In hot weather keep a new section shaded for 3 days. In any season, as soon as the concrete has set up so that water will not wash out the cement, sprinkle that portion of the floor and keep it well wet for 48 hours. Thereafter flood it with water morning and noon for a week.[1] At the end of that time the floor may be used for strictly feeding purposes, but must not be subjected to heavily loaded wagons for a month. While the floor is new keep loose animals off its surface.

FEEDING FLOORS FOR CATTLE.

Make feeding floors for cattle 5 inches thick. If the dimensions of the future racks are known, they may be securely fixed in place by setting short lengths of gas pipe in the floor into which iron pins or bolts are later inserted to lock the racks to the floor.

If watering tanks and feeding troughs and racks are located on the floor, see instructions governing the same under "General method of construction," page 14. Likewise for dipping vats, see "Concrete dipping vats," page 26.

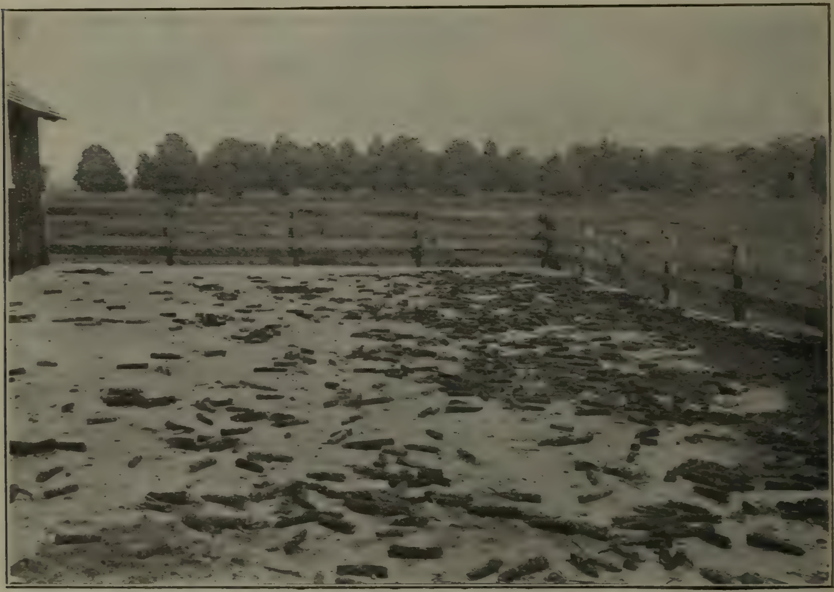


FIG. 10.—Cattle and hog feeding floor.

FEEDING FLOORS FOR HOGS.

Feeding floors for hogs should be 5 inches thick. See that the concrete apron around the edge extends deep enough into the ground that the hog wallows will not undermine the floor and cause it to break off.

Watering and feeding troughs for hogs are, as a rule, merely long, shallow concrete blocks, hollowed out to a V shape or U shape.

The outside form is a heavy box with vertical sides and ends. To get the full capacity of the trough, use a carpenter's level to set the outside form. On account of the slope of the floor, it will be necessary to tack a strip on the outside of this form to cover the cracks between the floor and the level form. The inside shape is given by a core made by tacking together two boards along one edge. Bevel these boards at the joint, so as to give a round shape to the bottom of the finished trough.

---

[1] As soon as the floor is hard enough to stand it, some farmers prefer to bed it down well with clean straw or hay and to keep the straw wet.

As soon as the concrete floor is laid where the trough is to be located immediately set the outside trough form in place. The core is then placed in the outside box form and spread at the top until it has the same vertical height as the outside form. To keep the forms in their proper position, nail crossties to both. Make the top edge of the finished trough at least 3 inches thick. To fill the forms through this small opening, mix the concrete wet enough to pour and add a little extra cement.

FIG. 11.—A good hog feeding floor.

Another method of building this same trough requires an outer form only. Mix the concrete dry enough that it may be tamped against the side of the form into the V shape or U shape desired. Paint the inside at once with cement and water mixed to the stiffness of cream.

Use 2-foot lengths of 1-inch gas pipe, crosswise, as shown in figure 12, to keep the hogs out of the trough. For holding the pipe in position, set ½-inch bolts in pairs, heads down, in the soft concrete so that the pipes will fit between them and can be held firm by a strap iron over the bolts. For this purpose choose ½-inch bolts of sufficient length to extend 4 inches into the concrete. Space the cross pipe 12 to 16 inches apart.

Post holes, for a removable fence of woven wire on 1-inch gas pipe, may be made by setting in the floor, flush with the surface, short lengths of 2-inch gas pipe or small drain tile. Such a temporary fence will keep the poultry off the floor until the hogs have finished their feed.

If a dipping vat is to be built in connection with the floor, see "Concrete dipping vats," page 26.

FEEDING FLOORS FOR SHEEP.

Feeding floors for sheep are built the same as for hogs. For the method of fixing feed racks see instructions governing the same under "General method of construction," page 14.

FEEDING FLOORS AND SWIMMING POOLS FOR POULTRY.

Unless subject to heavy wagon traffic, a 3-inch thickness is sufficient for concrete floors for the poultry yard. Construct dust boxes and swimming pools in the manner laid down for watering tanks and feeding troughs under "General method of construction," page 14. However, it is better to build the swimming pool just off the floor.

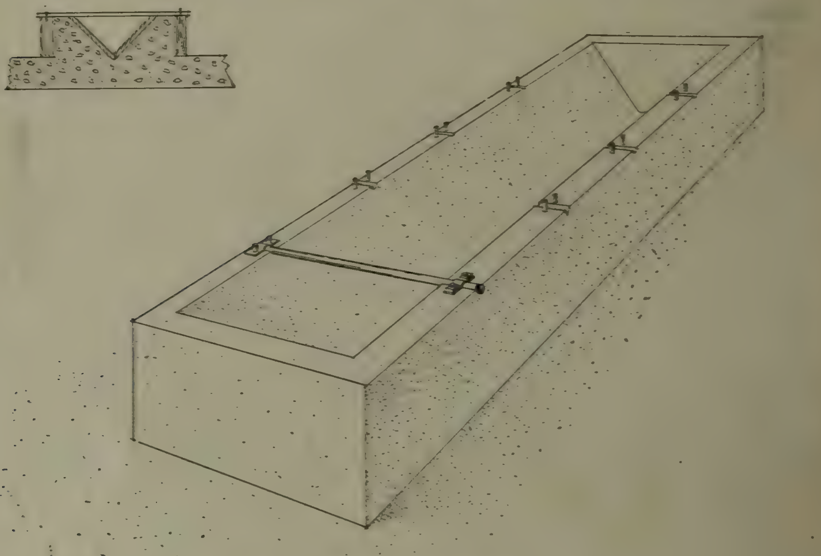


FIG. 12.—Feeding trough for hogs.

. For a pool dig out a basin 8 inches deep, and lay the necessary pipe and drains. Place the concrete in sections 4 inches thick and embed in it, 1 inch below the surface, widths of woven-wire fencing. At the edge of the pool extend the concrete above the ground into a curb so as to make the pool as deep as desired.

THE COST OF CONCRETE FLOORS.

The cost of a concrete floor is dependent upon so many conditions that no exact estimate can be given. The price of materials and labor vary considerably in different sections. And, most important, the managing ability of men is never the same in two instances. In general, however, for 1 square foot of surface the cost in cents is equal to the thickness of the floor in inches. For instance, a floor 5 inches thick will cost 5 cents per square foot of surface

CONCRETE MANURE PITS.

ORDINARY METHODS OF STORAGE WASTEFUL.

For maintaining or restoring the fertility of the fields, there is nothing better than barnyard manure. By the ordinary methods of piling manure on the ground or storing it in wooden pens and boxes, 30 to 50 per cent of its fertility is lost. This loss is brought about in two ways: First, by leaching or washing due to heavy rains; second, by fermentation or heating caused by lack of sufficient moisture. Since concrete pits are waterproof, manure may be kept in them as moist as may be necessary and such an enormous waste in the fertility of the manure may thus be entirely prevented. One load of manure from a concrete pit is worth 1½ to 2 loads of manure as usually stored. Moreover, with concrete pits the supply of manure is increased by all the liquid manure, the richest part, from the barn gutters and feeding floors.

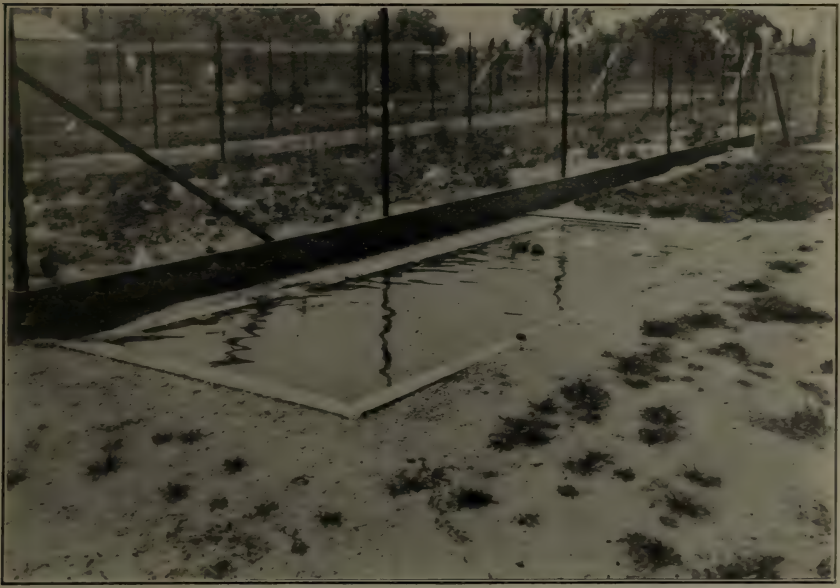


FIG. 13.—Concrete swimming pool for ducks and geese.

SHALLOW MANURE PITS.

Shallow manure pits do very well where the manure can be frequently hauled to the fields. In figures 17, 18, and 19 are shown plans for such a pit adjoining a feeding floor. The walls and floor are 5 inches thick. The clear dimensions of the pit are: Depth, 3 feet; width, 6 feet; length, 12 feet. Dig the trench 3 feet 5 inches by 6 feet 10 inches by 12 feet 10 inches. By keeping the sides vertical only an inside form will be needed. Frame the sides and ends separately. For the sides cut the 1-inch siding 12 feet long and nail it to four 2 by 4 inch uprights 3 feet long and equally spaced. The end uprights for the sides are 2 by 4 inch pieces nailed flat to the siding; the others are also 2 by 4 but are nailed on edge. It is not necessary to cut these uprights to exact lengths; they may be allowed to extend above the siding. Make the siding for the end sections of the form 5 feet 2 inches long and at the ends nail it to the edge of two 2 by 4 inch uprights. Place a single 2 by 4 upright between each end pair. Cut four cross braces, 5 to 10 inches long, from 2 by 4 inch timbers. Have enough sections of woven-wire fencing, 7½ feet long, to cover the bottom of the pit.

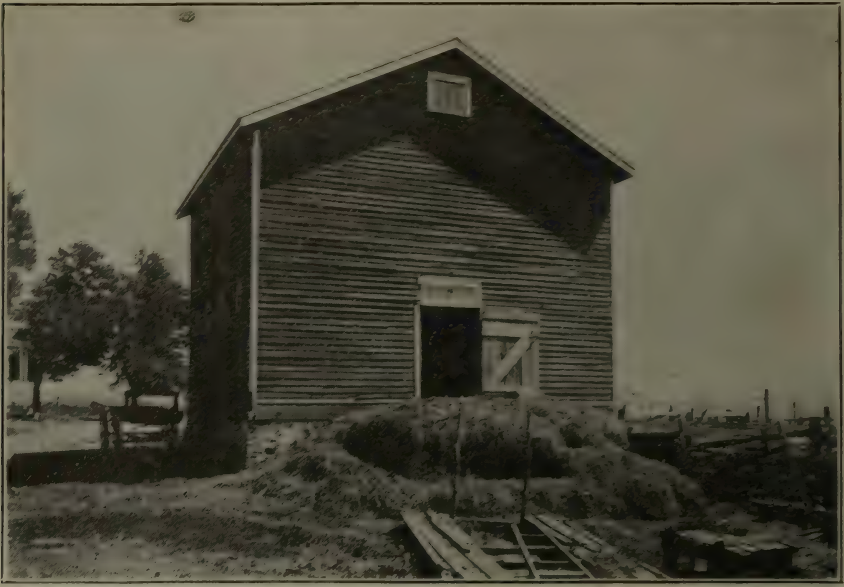


Fig. 14.—Old-fashioned method of storing manure, a large proportion being wasted by heating and leaching.

Mix the concrete 1 to 4 or 1 to 2 to 4, according to instructions on page 9. For measuring the materials use the same bottomless frame[1] described on page 9, but in this case for each batch of concrete increase the number of bags of cement to four. Crosswise, tamp in a section of concrete (not too wet) 2 inches thick and a little wider than the strip of woven-wire fencing used as reenforcing. Lay the wire with an even division of the extra length, so that it may project upward into the side walls. Tamp in the remaining 3 inches of concrete. Work rapidly and complete the floor. No facing mortar is needed.

Immediately set up the forms on the finished floor so as to allow a 5-inch wall on all sides. Join them by nailing together the 2 by 4's at the corners of the sides and ends. Do not drive the nails home. Cross-brace with 2 by 4's and with 1-inch boards from each central end upright to the second side upright.

---

[1] This box lacks three-eighths inch in height for an exact 1 to 4 or a 1 to 2 to 4 mixture. But the shortness is in sand and gravel (or rock) and merely makes a better concrete.

Quickly begin filling the forms with concrete almost wet enough to pour, and keep it practically the same height on all sides. Puddle the concrete by running a long paddle up and down next to the form. Do not punch the earthen wall. Dirt in the concrete may make a poor wall. If the top of the earthen wall tends to crumble, hold it back with 1-inch boards braced against the forms. To keep out flood water, the pit may be extended 6 inches above the ground by using the lower half of a 1-foot board to hold back the dirt, by allowing the remainder to project above the ground level, and by adding 6 inches to the height of the inside form. Remove the forms after the concrete has set four days by first drawing the nails in the corner 2 by 4's. The pit may be used after 10 days.

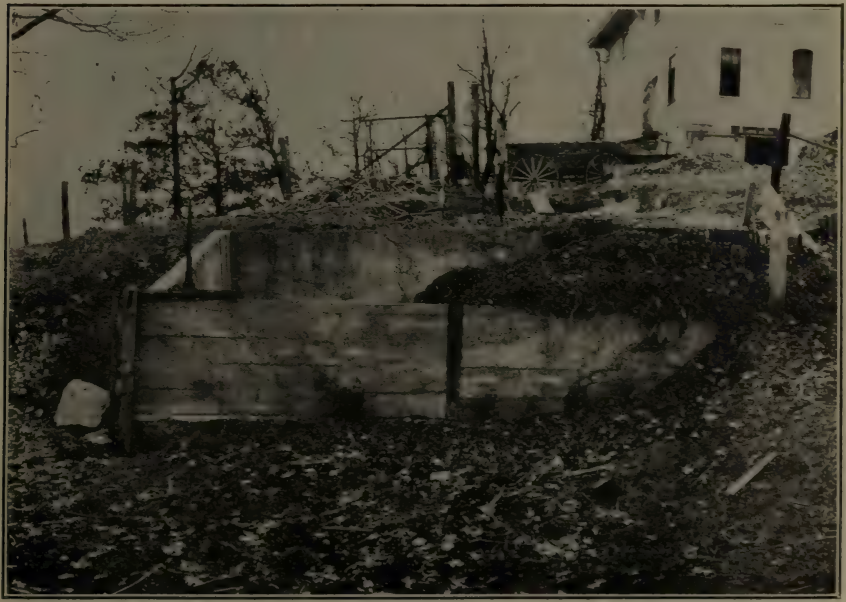


FIG. 15.—A concrete manure pit, by which all the manure may be saved.

MANURE BASINS.

Where manure must be stored for a considerable length of time, larger pits or basins are required. Such pits are seldom made over 5 feet deep (in the clear at the deeper end) and are wide enough that the manure may be loaded on a spreader in the pit and drawn up a roughened concrete incline or run. The slope for such a run must not be steeper than 1 foot up to 4 feet out.

In building such a basin as planned in figure 15, use a team with a plow and scraper to make an earthen pit in which to build a concrete basin of the clear dimensions shown. In laying out the earthen pit, bear in mind that the concrete walls and floor are 8 inches thick and make due allowance for the same. With a spade trim the sides and the deep end vertical.

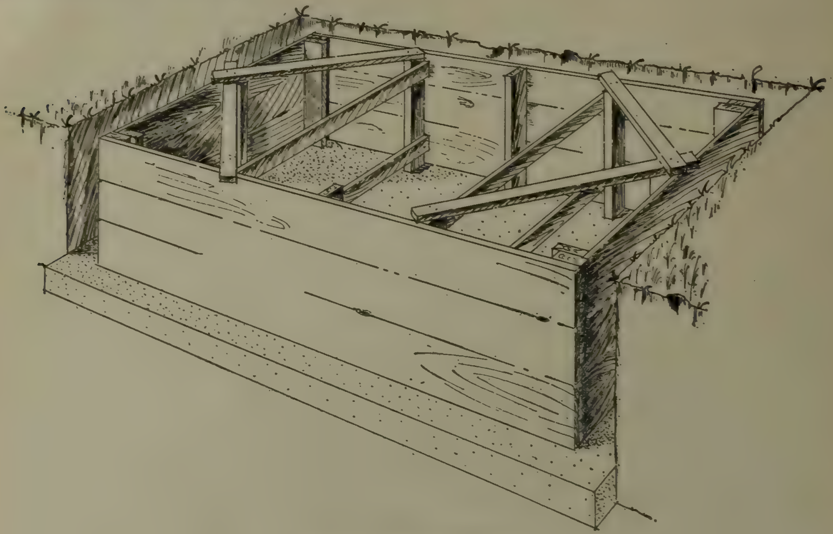


FIG. 16.—Manure pit forms.

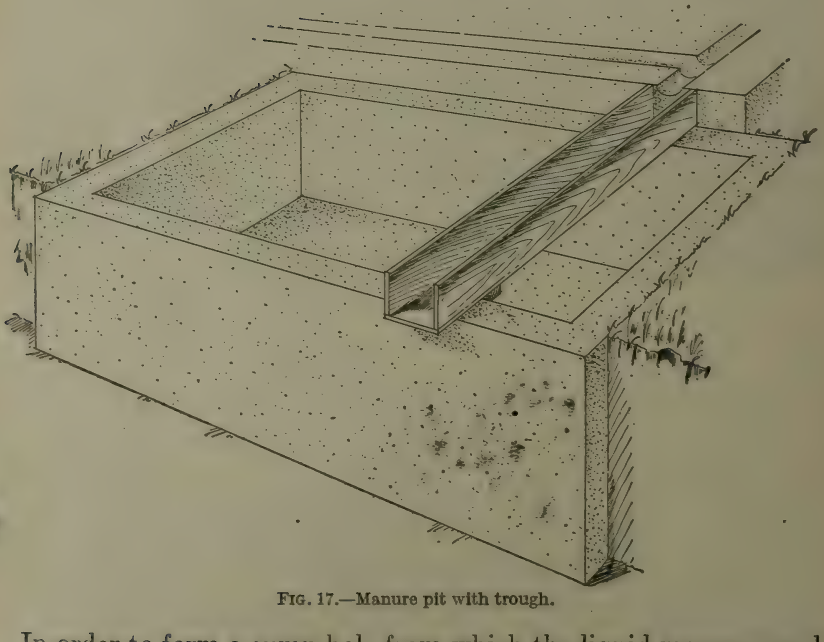


FIG. 17.—Manure pit with trough.

In order to form a sump hole from which the liquid manure can be pumped, in one corner at the deep end of the pit dig a hole 18 inches deep by 2½ feet in diameter. To protect the concrete floor, at the upper end of the driveway excavate a trench 8 inches wide and 2 feet deep for a concrete foundation apron. Extend it around the corners and slope it upward to meet driveway incline.

In general, the framing of the forms is similar to that of shallow pits. If the earthen walls stand firm, only an inside form will be needed. Otherwise, build an outer form. For the forms use 1-inch siding on 2 by 4 inch studding spaced 2 feet 8 inches. These uprights need not be cut to exact lengths. Save lumber by allowing them to extend above the siding. Stiffen each section of the form by nailing a 2 by 4 inch scantling to the uprights at top and bottom of the forms.

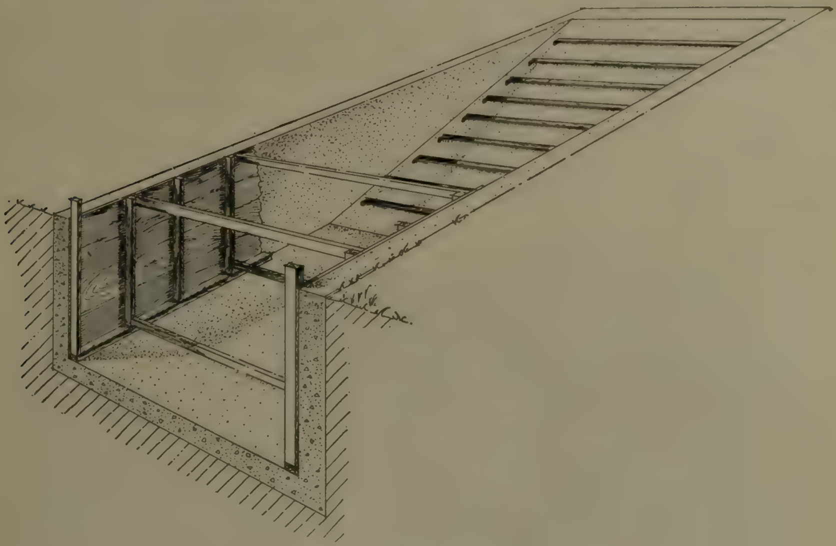


FIG. 18.—Shallow manure pit.

Erect the forms in the pit. Set them on 8-inch concrete blocks or bricks, so that the floor may be built under them. To prevent bulging, cross-brace the forms with 2 by 4 inch timbers. Begin filling with concrete, as for "Shallow manure pits," page 21, and do not stop until the job is completed.

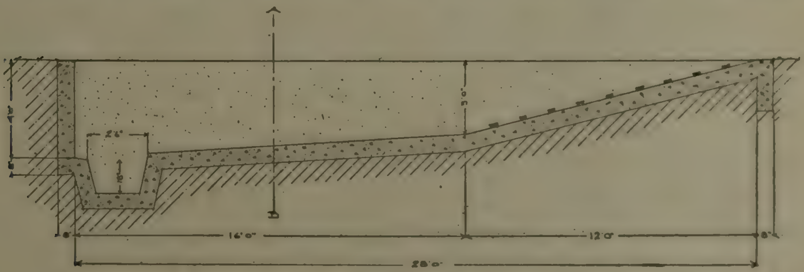


FIG. 19.—Section of shallow manure pit.

Lay the floor for the bottom and the incline the same as for shallow pits. To give teams a sure footing on the incline, embed in the concrete the turned-up ends of iron cleats bent at right angles, similar to a capital U. Old wagon tires, cut in lengths not greater than 20 inches and turned up 4 inches at each end, will do. Leave 1 inch clearance between the cleats and the concrete, and set them so as not to obstruct the wheelway. Space the cleats 14 to 16 inches. Roughen or corrugate the bottom crosswise every 6 inches by using a 5-foot length of 2 by 4 inch scantling beveled lengthwise to the shape of a carpenter's chisel. To make the corrugations, set the timber with the beveled face toward the incline. Strike the 2 by 4 with a heavy hammer, so as to indent the concrete to the depth of 1 inch.

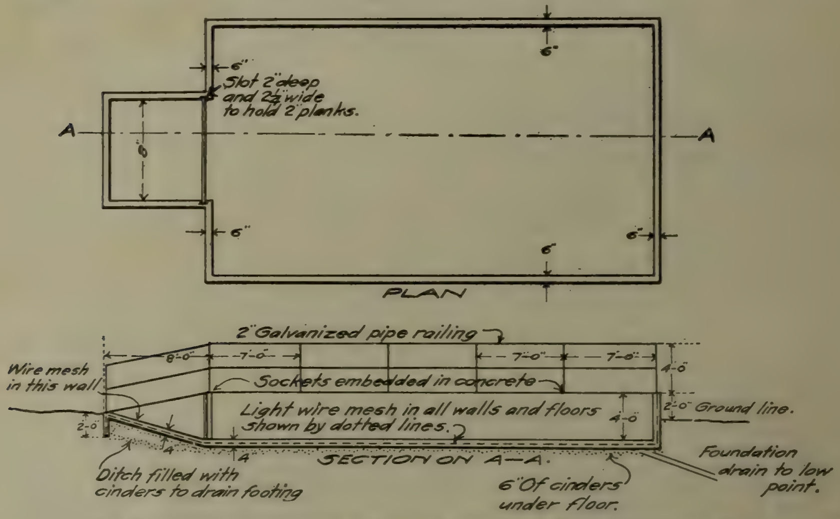


FIG. 20.—Drawing of a manure pit for the Morgan Horse Farm, Middlebury, Vt.

CONCRETE DIPPING VATS.

Dipping in certain solutions has been found to be the most effective means of ridding animals of vermin which infest the skin, such as the Texas-fever cattle tick, the scabies mite, lice, etc.

The "dips," as these remedies are called, are best applied by forcing the animals through vats containing solutions of them. Under average farm and ranch conditions the actual cost of dipping is very small. Of this cost the dipping solution, ready for use, makes up the greater part. Since it must be applied once or twice yearly, and the vat, of necessity, must be sunk in the ground, a water-tight vat of some permanent material is needed. On account of its lasting qualities, concrete has been found to be an excellent material for dipping vats.

There are five important points to be considered in the building of a dipping vat:

(1) A blind chute—an inclined chute with a turn, so that the animal can not see where he is going.

(2) An entering slide, steep enough to shoot the animal in, without a full drop. A direct drop, the entire depth of the tank, is liable to injure the animal.

(3) The vat must be narrow enough to prevent the animal turning around, long enough to keep him in from one to two minutes, and deep enough not only to force him to swim, but also to make him disappear entirely when he takes the plunge.

(4) The slope at the leaving end must be gentle and its surface roughened or cleated, so that the animal may easily climb out to the dripping pens.

(5) As the liquid dip is the most expensive part of the operation, there should be provided two dripping pens draining into a settling tank or trough.

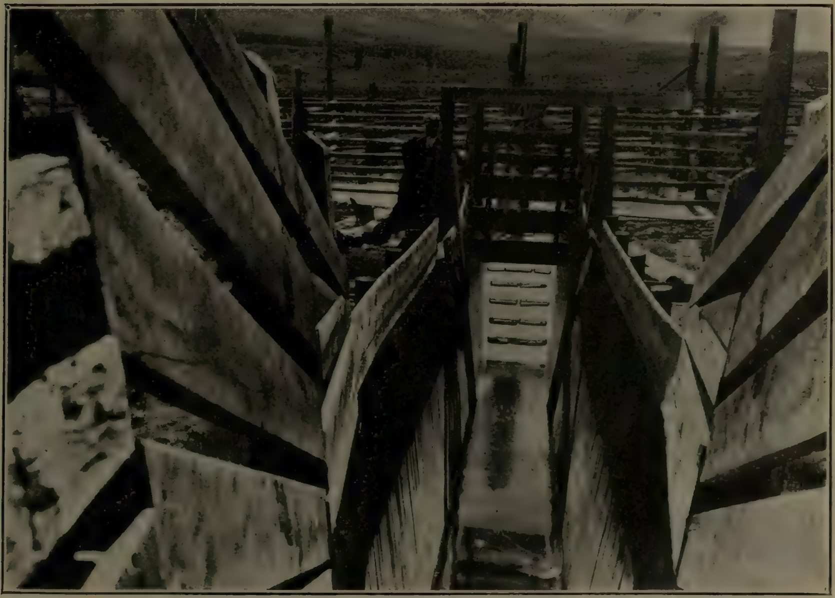


FIG. 21.—Concrete horse and cattle dipping vat, showing "soaking gate" raised. This vat may be transformed into a sheep vat by running a wooden partition the length of the vat. The cleats at the far end are made of wagon tires.

In locating the dipping vat, select a well-drained site handy to a water supply and convenient for a chute leading from a small, well-fenced lot or corral. (Consider also the means to be used in heating the dip in case this is required.) At the narrow end of the chute and in line with it, lay out the dipping vat with the entering slide abutting the chute. Often the chute is built on a curve, so that the animals can not see what is ahead of them.

One shape, with modifications as to size, is common to dipping vats for horses, cattle, sheep, and hogs. The vat is merely a box with sloping ends to make easy the animal's entering and leaving. From the table on page 32 and the plan shown in figure 24, choose the proper dimensions according to whether the tank is intended for horses, cattle, sheep, or hogs.

The lengths given will keep the animal in the vat one minute, which is usually a sufficient time. Where a longer treatment is desired, most ranchmen, instead of building vats of greater length, provide a drop gate working in a groove and controlled by a rope over a pulley, by means of which the animal is kept in the vat as long as necessary. Likewise, rather than build a separate vat for sheep and hogs, stockmen insert a temporary division fence, running the full length and depth of the cattle and horse vat. This fence should be solid and so spaced as to prevent hogs and sheep from turning around in the vat. In this way a single dipping vat may be used for horses, cattle, sheep, and hogs.

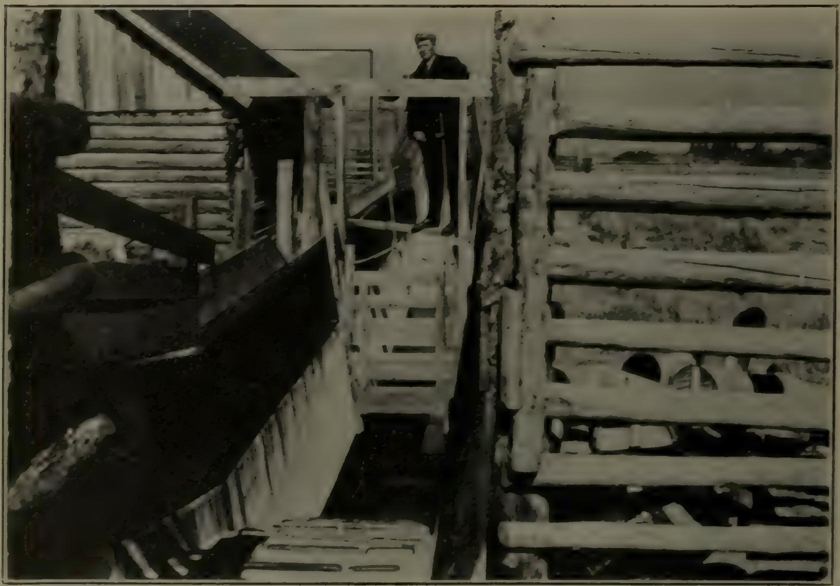


FIG. 22.—The same vat; view in opposite direction, showing "soaking gate" lowered for use.

Dig the deep part of the hole first, and then slope the earth for the slide and climb. Lay the outlet drain pipe so that the top of the elbow bend will be even with the surface of the finished concrete bottom. Tamp back the dirt thoroughly about the drain tile before placing the concrete. If a pump or a steam siphon is to be used to remove the dip, slope the earthen bottom to a sump hole in which the pump or siphon pipe can be set.

The side walls only will require forms. If the banks stand firm, inside forms alone will be needed. Otherwise, cut away the banks so long as they crumble, and build an outside form similar to the inner form, but enough larger to provide for the thickness of wall required.

Make the inside form of 1-inch boards on 2 by 4 inch uprights. Mix the concrete 1 to 2 to 4 (according to directions under "Shallow manure pits," p. 21), and lay the floor and slopes directly on the solid earth. No fill or drainage foundation is necessary. The concrete for the sloping ends should be mixed fairly dry so that it will tamp well and stay in position without the use of forms. With the bottom and slopes built, lower the side-wall forms into the pit. Take care to jar no dirt upon the concrete already placed. Space the forms properly and cross-brace them firmly upon each other. Fill the wall space with concrete mixed mushy wet. For large vats, set the forms before laying the floor, as directed under "Manure basins," page 23.

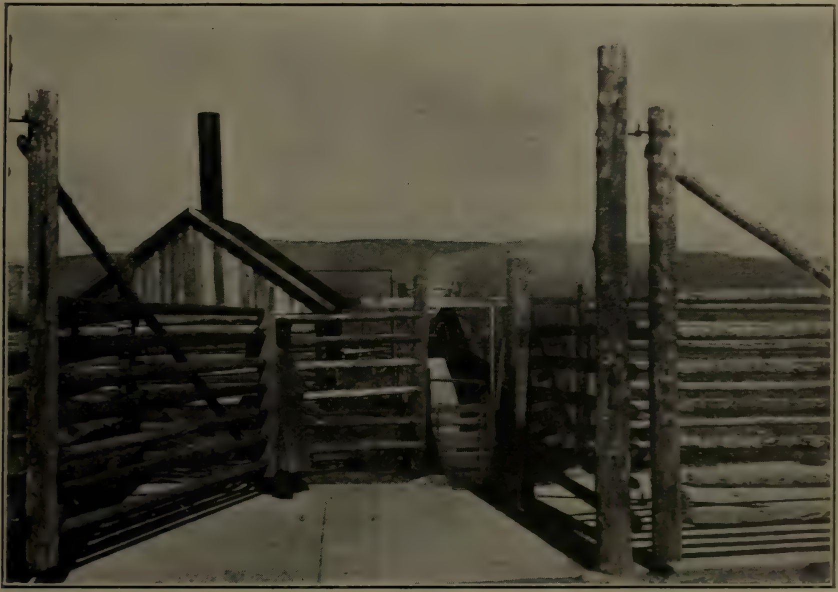


Fig. 23.—The same vat, showing double draining pens and arrangement of gates. Note shifting gate and boiler house with steam pipe leading to vat.

In placing this concrete, be sure that it strikes the wood form instead of the earthen side, as concrete mixed with earth makes a weak, leaky wall. Carry the walls 6 inches above the surrounding ground to prevent flood water from running into the vat. Have everything at hand and work rapidly, so that the whole vat may be finished at one time and without stopping.

The entrance slope should be smooth to slide the animals into the vat without skinning them up. Finish this surface with a wooden float and a steel trowel. Some ranchmen prefer to cover the entire slide with a polished steel plate, the edges of which are sunk into the concrete when the slide is built. If preferred, bolts may be set in the green concrete slide, clear of the animal's path, to which the steel plates are later bolted. To aid the animals in climbing out, embed in the concrete the turned-up ends of iron cleats bent at right angles similar to a capital U. Old wagon tires, cut in lengths not greater than 20 inches and turned up 4 inches at each end, will do. To better the footing, leave 1-inch clearance between the flat surface of the cleats and the concrete. Space the cleats 18 to 20 inches for horses and cattle and 10 to 12 inches for sheep and hogs.

DRAINING PENS.

At the leaving end of the vat, lay out the two dripping pens with their division fence on a line with the center line of the vat, so that the gate at the dipping vat, hung to this fence, may close either pen, when it is full, and allow the animals from the vat to pass into the empty pen. Use concrete posts for the fences, as they will require no replacing. Excavate for the drainage foundation, set the posts, and build a 6-inch concrete floor according to the directions given under "Feeding floors," page 18. Slope the floors one-fourth inch to each foot in length or width, so that the dip running off the animals will be saved and drained back to the vat. Corrugate or groove the floor (according to directions under "Manure basins," page 23), to the depth of one-half inch every 8 inches, in one direction. During the construction of the floor, mold around the outside a concrete curb, 6 inches above the floor and 4 inches wide. Where the dip from the floor empties into the vat, place a removable wire screen or strainer to keep the droppings and wool tags out of the vat.

Cure the floors and slopes according to directions under "Feeding floors," page 17. The wall forms may be removed after one week, but the vat should not be used until it is 3 weeks old.

Figure 24 shows a plan for draining the dip from the draining pens back to the vat which is much more convenient than strainers, and permits the floors of the drain pens to be made with very slight fall, thus preventing the animals from crowding to the rear of the drain pens after being dipped.

A shallow trough, about 8 or 10 inches deep and 8 inches wide, is made from the side of the incline from the vat along the edge of the drain pen, or in the case of a double pen, on both sides of the incline. At any convenient point, insert a 2-inch iron pipe into the trough, 2 inches below the top of the trough, and run this pipe to the vat. The dip drained from the animals will run to the trough, the solid matter washed into the trough will settle to the bottom and the liquid will drain through the pipe back into the vat. As solid matter accumulates it is shoveled out of the trough. By making a hole in the far end of the trough and inserting a plug, rain water can be drained away from the vat when it is not in use.

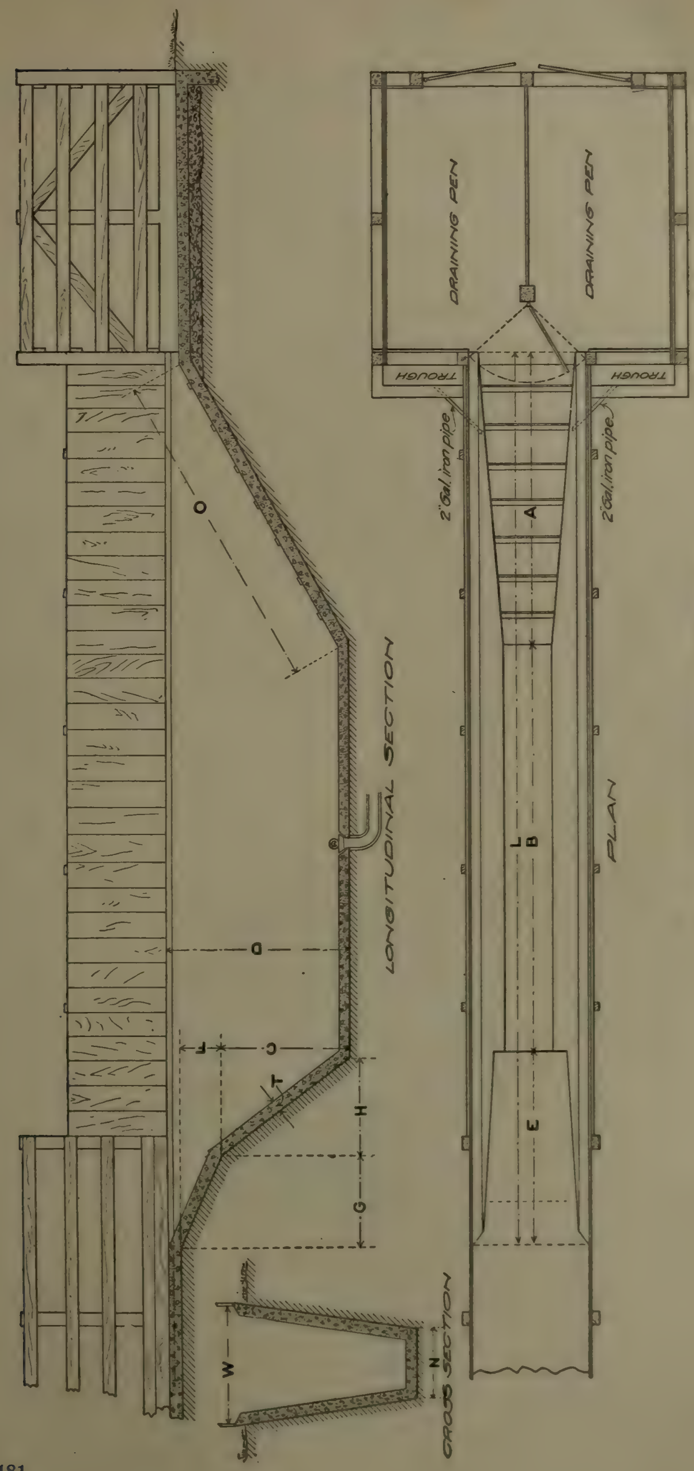


FIG. 24.—Details of construction of a dipping vat.

DIMENSIONS OF GROUND PITS FOR DIPPING VATS.

The dimensions of ground pits for dipping vats are shown in the following table, the letters at the heads of each column corresponding to those shown in figure 24:

Kind.	*W*		*N*		*D*		*L*		*E*		*B*		*A*		*G*	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Horses	5	10	3	4	8	8	55	0	7	6	31	0	16	6	3	9
Cattle	5	4	3	4	7	8	51	0	6	8	31	0	13	4	3	4
Sheep	3	4	2	4	5	8	46	0	5	0	31	0	10	0	2	6
Hogs	3	4	2	4	5	8	36	0	5	0	21	0	10	0	2	6

	F		*H*		*C*		*O*		*T*		Cement.	Sand.	Rock.
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Barrels.*	*Cu. yds.*	*Cu. yds.*
Horses	2	2	3	9	3	9	18	7	0	8	43	13	26
Cattle	1	11	3	4	3	4	15	4		8	37	11	22
Sheep	1	5	2	6	2	6	11	6		8	24	7	14
Hogs	1	5	2	6	2	6	11	6		8	19	5½	11

CARE OF CONCRETE DIPPING VATS.

Concrete dipping vats need no care other than covering them up or so inclosing them that persons and animals can not accidentally fall into them. Concrete is not injured by moisture. It will not rot or rust out. It requires no repairs. A concrete dipping vat, built of good materials and properly constructed, will always be ready for use and lasts forever.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued February 14, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 482.

THE PEAR AND HOW TO GROW IT.

BY

G. B. BRACKETT,
Pomologist, Bureau of Plant Industry.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

U. S. SUPT. OF DOCUMENTS.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 25, 1911.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "The Pear and How to Grow It," prepared by Col. G. B. Brackett, Pomologist.

This paper is designed to give practical directions for the guidance of the amateur, as well as for the farm orchardist. The information contained is based largely upon the experience of the writer of this paper.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

CONTENTS.

Page.

Introduction 5

Dwarf and standard trees 6

- Dwarfs 6
- Standards 7
- Converting dwarf trees into half standards 7

Propagation 7

- Seeds 7
- Budding 8
- Grafting 9
- Double-working trees 9

Location of the orchard 9

- Soil 10
- Drainage 10

Fertilizers 10

- Green manures 11
- Commercial fertilizers 11

Planting the orchard 11

- Season for planting 11
- Preparation of the ground 11
- Setting the trees 12
- Distance for planting standards 13
- Distance for planting dwarfs 13

Selection of trees 13

- Varieties to plant 13
  - Amateur list 14
  - Commercial list 14
  - Dwarfs 14
- Fertilization 14
- Where to obtain trees 14

Cultivation 15

Cover crops 15

Pruning and training 16

- Objects to be attained 16
- Form of top 18
  - Vase or goblet form 18
  - Pyramidal form 18
  - Intermediate or natural form 19
- Height of top 19

Protection from rodents 20

Diseases and insect enemies 20

- Pear blight 20
- Pear scab 21
- Insects 21

Thinning the fruit 22

Gathering the fruit 22

Sorting and grading the fruit 23

Packages 24

The fruit room 24

Disposing of the crop 25

Abridged descriptions of select varieties of pears 25

- Bloodgood 25
- Clapp Favorite 26
- Giffard 26

Abridged descriptions of select varieties of pears—Continued. Page.
Bartlett 26
Rostiezer 27
Brandywine 27
Tyson 27
Flemish (*Flemish Beauty*) 27
Lucrative (*Belle Lucrative*) 28
Bosc 28
Louise (*Louise Bonne de Jersey*) 28
White Doyenne 28
Seckel 28
Sheldon 29
Anjou 29
Kieffer 29
Angouleme (*Duchesse d'Angouleme*) 29
Comice 30
Danas Hovey 30
Lawrence 30
Winter Nelis 30
Easter Beurre 31
Summary 31

ILLUSTRATIONS.

Page.
Fig. 1. Dwarf pear orchard 6
2. Budding 8
3. One-year-old pear tree 16
4. Two-year-old pear tree 16
5. Vase or goblet form of top 17
6. Pyramidal form of top 18
7. Intermediate or natural form of top 19
8. Bartlett pear orchard, showing manner of picking the fruit by the use of ladders 23
9. Bloodgood pear 25
10. Clapp Favorite pear 26
11. Giffard pear 26
12. Bartlett pear 26
13. Rostiezer pear 26
14. Brandywine pear 27
15. Tyson pear 27
16. Flemish pear 27
17. Lucrative pear 27
18. Bosc pear 28
19. Louise pear 28
20. White Doyenne pear 28
21. Seckel pear 29
22. Sheldon pear 29
23. Anjou pear 29
24. Kieffer pear 30
25. Angouleme pear 30
26. Comice pear 30
27. Danas Hovey pear 30
28. Lawrence pear 31
29. Winter Nelis pear 31
30. Easter Beurre pear 31

B. P. I.—712.

THE PEAR AND HOW TO GROW IT.

INTRODUCTION.

The pear has long been regarded as one of the most luscious of the many kinds of fruit brought under cultivation. The choice varieties excel most apples in rich, juicy texture and delicacy of flavor, and for both dessert and culinary purposes, either canned or in the fresh state, the pear is considered a great acquisition. With a proper selection of varieties and with careful handling and storing of the fruit its season of use may be extended from midsummer to late winter without resorting to artificial means of preservation.

Pear trees are more difficult to maintain in a healthy, productive condition than apple trees and can not be grown with the same degree of success over so wide an area of country. Such has been the uncertainty of success in growing pears in many parts of the United States that few farmers have the needed confidence to plant even the few trees necessary to provide fruit for home use. This lack of confidence too often leads to neglect, which in many instances becomes the prime cause of ultimate failure.

The information in this bulletin is based on practical experience and should bring success to the planter in any locality where the pear flourishes. By following these details the farmer will be enabled to grow enough choice fruit to supply his own family; and if he should wish to extend his planting for market purposes he will find a ready sale for his surplus crop. With these objects in view care should be given to the selection of varieties.

Two distinct classes or types of the pear are now grown in this country: (1) The European and (2) the Asiatic, or oriental.

The European type is a native of Europe; from it most of our domestic varieties have sprung. Pears of this class are well adapted to the New England States, New York, and other States southward and westward to California, Washington, Oregon, and Idaho. In the States named beyond the Rocky Mountains extensive commercial orchards have been planted with choice varieties of this class of pears, the Bartlett leading all other varieties in commercial plantings.

The Asiatic, or oriental, type is of comparatively recent introduction. In its natural condition it is scarcely an edible fruit and must receive an admixture of our improved European varieties in order to render it at all acceptable. The more important varieties grown in America are hybrids, the results of artificial or accidental crossing with our domestic pears of European origin. To this class belong Le Conte, Kieffer, Garber, Smith, and other hybrids. While these are not considered as valuable for dessert use in the fresh state as varieties of the European type, they are much esteemed for canning and culinary purposes. These hybrids are very productive and well adapted to a wide range of country extending from New Jersey, Delaware, Maryland, and Virginia southward to Florida and Texas. In some of these States the industry has grown to large proportions. The Kieffer and Le Conte are the varieties of the oriental type that have gained the greatest commercial prominence.

FIG. 1.—Dwarf pear orchard of Albert Wood, Carlton Station, N. Y.

DWARF AND STANDARD TREES.

DWARFS.

Trees propagated by budding the pear upon quince stock are known as dwarfs. The Angers variety of quince is principally used for this purpose. Such trees develop a fibrous root system, are dwarfed in habit and generally productive, and come into bearing early. Some varieties succeed better on quince stock than on pear stock.

The dwarf type of tree may be advantageously used on small city lots, but in some of the Eastern States there are many large and profitable commercial pear orchards of small size which yield fine crops of fruit. (Fig. 1.) Pears of European origin are not adapted to the Southern States except in the more elevated localities.

STANDARDS.

Trees produced by grafting or budding improved varieties on seedling pear stock are known as standards. They are comparatively longer lived than dwarfs and in time becomes larger trees, capable of yielding heavier crops of fruit, but they usually come into bearing more tardily than dwarf trees.

CONVERTING DWARF TREES INTO HALF STANDARDS.

A method often practiced with good results is known as the "lipping process." It consists in making a slit with a sharp knife through the bark and slightly into the sapwood of the tree in an upward direction just above the union with the quince root on which it has been worked. At these lips a callus forms from which roots grow and these in time become strong enough to sustain the tree after the quince roots become inactive. The treatment must be given at the time of setting the trees, and they must be planted deeper than usual so that the point of union will be several inches under ground.

The gain by this process is that the dwarf tree, which comes into bearing early, eventually becomes a standard capable of bearing larger crops and being of greater longevity.

PROPAGATION.

It is hardly worth the farmer's time and trouble to propagate his own trees for planting, but he should have some definite idea of the processes and methods of propagation customarily practiced. The pear, like all other fruits, is subject to adaptation to environment. Pears do not certainly reproduce themselves true to variety when grown from seed; hence the necessity for budding or grafting in order to obtain the variety desired.

SEEDS.

The natural method of reproduction is by planting the seeds of the fruit, but the great majority of seedlings will produce fruit of a quality so inferior to the parent as to be practically worthless; results by this method are therefore too uncertain and disappointing for general adoption. But if seedlings are desired, good pear seeds germinate readily when saved from healthy, well-matured fruit.

The seeds should be stratified, i. e., mixed in alternate layers of moist sand in a box, covered securely to guard against rats and mice, and the box should be placed on the north side of some building where it will be exposed to freezing and thawing throughout the winter until the time for planting. If the seeds are planted in rows 3 feet apart in good soil and given thorough culture they will make a sufficient growth in one season for budding or grafting. If wanted for root grafting the seedlings should be taken up in the fall and stored in a cellar, where they will keep fresh and be accessible at any time during the winter; if wanted for budding they may be buried in the soil outside until the time of planting in the spring, when they may be set in nursery rows 4 feet apart with the plants 10 inches apart in the row.

The object sought by either budding or grafting is to convert an undesirable or uncertain seedling into a tree which will produce fruit known to possess desirable characteristics.

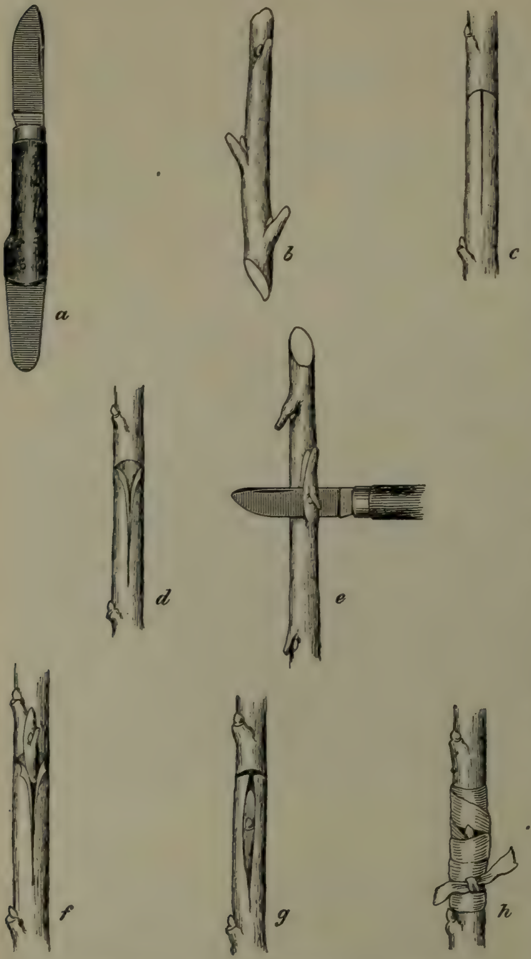


Fig. 2.—Budding: *a*, Budding knife; *b*, bud stick; *c*, lengthwise incision with cross cut at top; *d*, opening of bark for insertion of bud; *e*, removing the bud; *f*, inserting the bud; *g*, bud inserted; *h*, bud properly wrapped.

BUDDING.

The operation of budding, which must be performed during the growing season, consists in removing a bud from a twig of the desired variety and inserting it beneath the bark of the stock or young seedling which is to be changed. The inserted bud is held in place by wrapping it fast with soft cotton twine, bark, or raffia. In about 10 days the bud will have united with the stock and the wrapping may be removed. Then by cutting back the stock or limb to near the inserted bud, the sap is forced into the newly transplanted bud and the growth of a new tree of the desired variety is promoted.

A budding knife and the successive stages of budding are shown in figure 2.

The main requisites for success in budding are (1) a healthy growing condition of the stock on which the work is to be done and (2) a certain state of maturity of the buds. The bark of the stock must separate freely, so that the bud may be forced under it without injury to the cambium layer of either bud or stock. The bud sticks or scions for budding should be of the current year's growth and should have well-developed buds. When the scions are taken from the tree the leaves must be cut off immediately, leaving only a short stub of the leaf stem for convenience in handling during the operation of budding. The bud sticks should be kept in fresh condition by means of damp moss or a wet cloth, and not more than one or two scions should be withdrawn from the package at a time.

Although budding may be done as early as well-developed buds can be obtained, the common practice of nurserymen is to insert the buds as late in the season as the bark of the stock will separate freely. By this method of late budding the bud is allowed to remain dormant through the following winter. In the spring the wrapping is removed and where the bud appears to be sound the top is cut back as already indicated. All buds on the stock below the one inserted should be rubbed off as they start to grow so as to throw all the sap into the growth of the bud inserted.

GRAFTING.

The process of grafting the pear is the same as that of the apple. The different methods of grafting have been fully described in "The Apple and How to Grow It," Farmers' Bulletin 113, of the United States Department of Agriculture, to which the reader is referred.

DOUBLE-WORKING TREES.

In propagating dwarf pear trees, the Angers quince is used as a stock on which to bud the pear, but there are some varieties of pear that do not unite well with the quince; with such varieties the method known as "double working" is used. This process consists in budding the quince stock with a variety of pear that is known to unite well with the quince; then when this has grown to a sufficient size it is top-worked to the desired variety.

LOCATION OF THE ORCHARD.

In locating a pear orchard, special reference should be given to soil, exposure, air, and water drainage. Elevated ground sloping to the east, northeast, or north is regarded as preferable. With such an exposure the sap is more backward in starting in the spring; the trees bloom later, and consequently are less liable to injury from late spring frosts. Trees planted on ground sloping to the south, southwest, or west and exposed to the direct rays of the sun are liable to sun scald, which in some sections results in serious damage or even death to the trees.

SOIL.

The pear succeeds on a variety of soils. In a general way it may be said that the pear may be grown with a considerable degree of success in almost any soil in which the apple thrives.

For standards a clay loam having a deep, porous subsoil, such as may be found in forest clearings, into which the roots will naturally penetrate, is most desirable. In such locations decaying leaves and forest herbage have added much necessary humus to the soil, rendering it more moist and friable.

A clay loam such as has been described may be brought to the desired state of tilth by a good system of mulching and green manuring, and trees planted in it find the available plant food so necessary to maintain a healthful growth. Trees grown in such a soil are more disease resistant, and the conditions are favorable for enduring drought and the extremes of heat and cold. Under proper soil conditions pear trees attain greater longevity, maintain a greater fruitfulness, and the product is of high quality.

Dwarfs worked on the quince naturally develop a fibrous root system which thrives best in rich, humus, moist soil having a subsoil of porous clay.

DRAINAGE.

It is essential to the health of the pear that no surplus or stagnant water be allowed to remain on the surface or in the soil.

If the natural formation of the land does not afford good drainage it should be provided artificially either by underground drains or by surface ditches. The subdrainage method is preferable because it is more thorough and, if accomplished by well-laid tile, is far more satisfactory.

Breaking up stiff clay land by double-plow subsoiling will in a measure afford temporary subdrainage, but in time the soil will again become compacted and the subsoiling will need to be repeated.

FERTILIZERS.

The use of fertilizers in pear culture requires most careful consideration and judgment. Lands naturally fertile, viz, loamy soils so common in prairie regions, cleared forest lands, and clayey soils having marl in their composition, should not be enriched. Tillable lands that will grow a good crop of corn are sufficiently fertile for the pear tree. When the pear orchard begins to lose its vigor from continuous fruit crops a light surface dressing of wood ashes or well-rotted stable manure may prove beneficial. As long as the trees maintain a normal healthy growth they require no stimulating food.

Trees that are highly stimulated and are making a rapid growth are much more liable to be attacked by blight, which is the greatest drawback to successful pear culture.

GREEN MANURES.

If humus is lacking in the soil and barnyard manure is not available, cover crops such as clover, cowpeas, vetch, etc., may be sown in midsummer after cultivation has ceased and the crop allowed to remain on the ground over winter and turned under in the spring. If this process is continued from year to year it will add greatly to the fertility of the soil as well as maintain it in suitable physical condition.

COMMERCIAL FERTILIZERS.

There are many kinds of manufactured fertilizers, some of which are valuable only for special soils or special crops. To determine what fertilizer is best to use, a knowledge of what elements are lacking in the soil is necessary. The three elements most commonly needed in soils for fruit growing are nitrogen, potash, and phosphoric acid. Chemical fertilizers which contain these substances in available form will be the most valuable.

A fertilizer containing 1½ to 2 per cent of nitrogen, 7 to 9 per cent of available phosphoric acid, and 10 to 12 per cent of potash will give good results on land that is deficient in these elements when applied in a quantity ranging from 400 to 600 pounds per acre.

PLANTING THE ORCHARD.

SEASON FOR PLANTING.

For sections south of about the forty-first parallel of latitude the fall is undoubtedly the best season for planting, but for most of the territory north of this line it is safer to plant in the spring. If planted in the fall in the North the roots of the tree do not throw out their feeders sufficiently to supply the moisture necessary to maintain the healthy flow of sap which is essential to prevent the shriveling of branches by the exhaustive winds during winter's extreme cold.

PREPARATION OF THE GROUND.

It is as important with the pear as with any other kind of fruit tree that the land, whether for standards or dwarfs, be well and thoroughly prepared by plowing and stirring the soil and subsoil deeply before planting.

The preparation can best be done in the fall, as the effect of freezing and thawing the ground through the winter improves the soil by pulverizing it.

An excellent plan is to plow the ground in lands in the direction that will afford the best drainage, backfurrowing with a heavy plow and leaving the dead furrows where the rows of trees are to be set. It is well to break up the bottom of this dead furrow by running a subsoil plow through it two or three times, giving it a good stirring. This method affords a deeper tilth under the trees and allows a partial underdrainage in heavy clay subsoil, if the rows are laid out with reference to this object, and is preferable to digging holes which would form basins that would hold water during rainy seasons, to the injury of the trees.

SETTING THE TREES.

After the land has been prepared as described it will only be necessary to open a furrow with a plow for the rows and to cross check to indicate the points to set the trees. The cross checking may be done with a 1-horse plow after having set stakes at the proper distance on opposite sides of the field as a guide for laying it off. Another method which will give more accurate alignment is to set a row of stakes through the center of the block each way, corresponding with stakes on the outside line. If these rows of stakes are properly aligned there will be no difficulty in planting the trees in straight rows each way. For convenience in large plantings the land should be laid out in blocks of 10 to 20 acres.

Preliminary to setting, the trees should be hauled to the land, distributed at convenient distances, and heeled in at the end of the rows in the dead furrow. After places have been properly prepared at the intersection of the furrows by simply leveling off the bottom of the furrow sufficiently to allow the roots of the tree to be put in a natural position, the trees may be set. Four persons are necessary to do the work of setting economically, viz, one to prune and distribute the trees along the rows, one to hold the tree in place, and two to shovel in the soil around the tree. The one that holds the tree first sights accurately its alignment with the center stake and the end stake beyond, while one shoveler makes the alignment of the cross row by sighting on the center stake and end stake of that row. Before setting the tree all broken and bruised roots should be cut back to sound tissue, and other roots shortened to within 4 or 5 inches of the trunk; all limbs of 1-year-olds should be removed from the top, leaving a smooth stalk, or whip, as it is called. The tree is now set in place with its roots in natural position, and fine dirt is shoveled in and trampled firmly with the foot. The tree should be set 2 to 4 inches deeper than when in the nursery, leaning it slightly to the south or southwest, to brace it against the prevailing winds and so that the top will protect the trunk of the tree from the intense heat of the afternoon sun, which is liable to cause sun scald. After the young tree is in place the top, if trimmed to a whip, may be cut back to within 12 to 15 inches of the ground. The open furrows between the trees may be filled up by using a 1-horse plow, turning two or more furrows toward the row.

DISTANCE FOR PLANTING STANDARDS.

A good distance for planting standard pear trees is 15 by 30 feet; that is, the rows are 30 feet apart and the trees 15 feet apart in the rows. The object of this method is to obtain larger crops of fruit from the same ground until the trees become large enough to interfere with each other; then each alternate tree in the row is cut out, leaving the trees in the entire orchard at a distance of 30 feet each way. This system has the advantage of more fully utilizing the land for fruit production until the thinning out becomes necessary. Another plan is to plant the trees 20 feet apart each way. This distance will afford free circulation of air and abundance of sunlight, both of which are essential to well-developed and highly colored fruit.

DISTANCE FOR PLANTING DWARFS.

Dwarfs are sometimes planted 10 feet apart each way, but 15 feet each way, or 193 trees to the acre, is better. This distance gives room to drive through the grounds for spraying and to gather the fruit.

SELECTION OF TREES.

Strong, well-rooted, 1-year-old trees are preferable to any other age, whether standard or dwarf.

As to the selection of standard or dwarf trees, every planter will be governed by the object to be attained. If early fruitfulness is desired, dwarfs are preferable; but it should be borne in mind that such trees are usually shorter lived and seldom attain large size. For these reasons they are better adapted to small lots or to garden purposes. Some varieties, such, for instance, as Anjou, Angouleme, Diel, Louise, etc., do better on the quince root than on the pear stock.

On the other hand, if longevity of tree, larger size, and capacity for producing heavier crops are desired, standards should be planted. It is well also to consider the character of the soil in the location selected as to adaptability of class desired, as explained under "Soils."

VARIETIES TO PLANT.

Pears vary in their season of ripening, so that if proper attention is given to the selection of varieties and to careful handling and storing, the pear grower may have fruit for his table or market from midsummer until March. Many varieties which are inferior in size, unattractive in appearance, or so tender in texture as to be disqualified for commercial purposes, yet possess qualities that render them of value to the amateur planter. The varieties in the following list are some of the most desirable, arranged approximately in the order of ripening:

Amateur list.—Bloodgood, Clapp Favorite, Giffard, Bartlett, Rostiezer, Brandywine, Tyson, Flemish Beauty, Lucrative, Bosc, Winter Nelis, Louise, White Doyenne, Seckel, Sheldon, Anjou, Kieffer, Angouleme, Comice, Danas Hovey, Lawrence, Easter Beurre.

Commercial list.—Varieties of attractive appearance, medium size, productiveness, and vigor of tree are of prime importance in planting a commercial pear orchard. The following are recommended: Tyson, Clapp Favorite, Bartlett, Bosc, Louise, Winter Nelis, Sheldon, Anjou, Kieffer, Comice, Lawrence, Easter Beurre. For the Central and Southern States: Le Conte, Kieffer, Garber.

Dwarfs.—Certain varieties of the pear do better on the quince stock than on the pear. Such varieties are as follows: Angouleme, Louise, Diel, Anjou, Clairgeau, Lawrence.

Many other varieties may be grown with fair success on the quince root, such as Bartlett, Bosc, Columbia, and White Doyenne.

FERTILIZATION.

Some varieties of pear are infertile by themselves and therefore varieties should be intermingled in planting in order to insure fruitfulness. No more than two rows of one variety should be planted together, alternating with some other variety that is considered a good pollinizer. The Anjou, Bartlett, Clapp, Kieffer, Lawrence, Louise, Sheldon, and Winter Nelis varieties are considered more or less self-sterile; the Angouleme, Bosc, Flemish, Seckel, Tyson, and White Doyenne varieties are generally self-fertile. It may be said, however, that self-fertile varieties under some conditions may become self-sterile under other conditions.

WHERE TO OBTAIN TREES.

It is always advisable to purchase trees from the nearest responsible home nurseryman whenever possible, thereby lessening the cost of transportation and the liability to damage by long transit and frost. Local nurserymen are more likely to be interested in filling orders with varieties true to name than the traveling salesmen, from whom redress is seldom possible in case the order is not filled properly.

CULTIVATION.

Thorough and frequent stirring of the ground between the rows with a cultivator should be done during the early part of the growing season or from early spring until July 1, when cultivation should cease so that the new growth of wood may harden up sufficiently to endure the winter temperature. This is especially essential in the Middle and Northern States, where a low temperature often occurs.

After the spring plowing the cultivation may best be done by using some kind of cultivator or harrow as often as it is necessary to keep the ground well pulverized.

After the trees have attained sufficient size and age to commence fruiting, cultivation may be discontinued for a while and the land seeded to clover. This cover crop will check the rapid growth of the trees and bring the trees into bearing sooner than if cultivation is continued. If the clover is allowed to fall on the ground instead of cutting and removing it, it will act as a mulch and serve to retain moisture in summer and be a protection in winter.

If desirable to grow other crops between the rows of trees as a matter of economy this may be done for a few years after being set out without any detriment to the orchard, provided the crop is of such a nature as to require thorough cultivation. To grow among the trees the first season after planting there is no better crop than corn. It requires thorough cultivation and affords a shade to the newly planted tree at the season when it most needs protection from the sun's greatest heat. Other crops, such as potatoes, cabbage, peas, beans, melons, etc., may be grown to advantage. Small grain or grasses which do not require cultivation should not be allowed in the newly planted orchard. All these crops take from the soil plant food which will be needed in time for the orchard's support and which should be returned in some form of manure.

COVER CROPS.

Cover crops, by conserving moisture and adding elements of fertility to the soil, are beneficial to the pear orchard. Among the desirable cover-crop plants are the clovers and legumes, such as cowpeas, beans, vetches, etc. These cover crops not only protect the roots of the trees from extreme cold and prevent the washing of land by fall and spring rains, but they afford that supply of humus so essential for the maintenance of the fertility of the soil and its physical condition. To obtain best results, cover crops should be left on the ground over winter and turned under in early spring by shallow plowing, so as not to disturb the roots of the trees. The kind of cover crop to be grown will have to be determined by climatic and soil conditions. Wherever crimson clover can be grown it is one of the best plants for a cover crop, but it fails to give general satisfaction in some of the Northern States. Among other plants sometimes used and of more or less value as cover crops are oats, rye, barley, and millet.

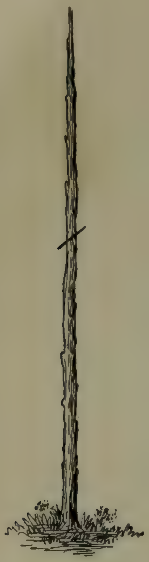


FIG. 3.—One-year-old pear tree. The line shows where to cut back at time of pruning.

If the practice of sowing cover crops and turning them under is continued from year to year, the land will gradually be enriched and the soil maintained in proper physical condition.

PRUNING AND TRAINING.

OBJECTS TO BE ATTAINED.

Pruning and training are important requisites in the successful management of a pear orchard. The objects to be attained are: (1) Symmetrical, evenly balanced heads; (2) the admission of sunlight and free circulation of air into all parts of the tree tops; and (3) the maintenance of sufficient foliage to protect the trunks and branches from the intense heat of the sun's rays which would otherwise be likely to scald and injure both tree and fruit.

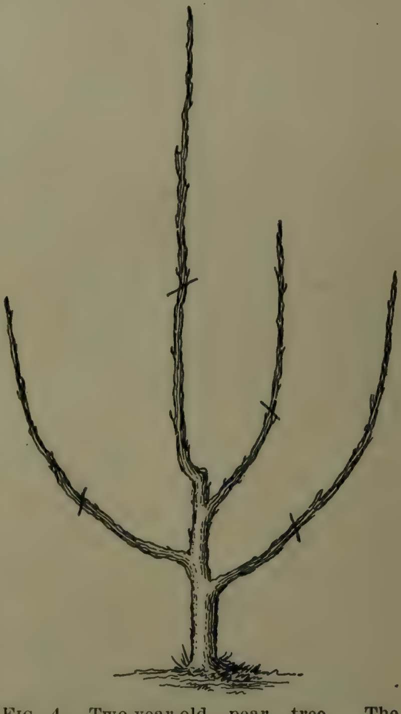


FIG. 4.—Two-year-old pear tree. The lines show where to cut back at time of pruning.

Pruning should begin as soon as the trees have been planted by cutting back the young tree at the time of planting to the height from the ground it is proposed to start the branches to form the head of the tree, which should not be over 12 to 15 inches, as shown in figure 3. This cutting back will cause several of the upper buds to break and grow, thus starting the top or head at the proper height. The starting branches should be watched and only such left to grow as are to form the main branches. The strongest shoots should be left at equal distances apart around the stem and should tend obliquely outward so as to spread and make an open head. The second year these shoots should be shortened back to the extent of about half of the growth, as shown in figure 4. The same plan should be continued the third and fourth years.

In all pruning, to give the desired form to the head and especially while the tree is young, the orchardist should keep clearly fixed in his mind the form of the tree as it is to be when old; for what may seem to be an open head when the tree is young may prove to be too dense and crowded when the tree is older. The branches should not be too close together for convenience in gathering the fruit.

During late winter or in early spring before the sap starts, each tree should be carefully looked over and all branches which are likely to interfere with adjoining ones should be cut out and the centers of dense growth thinned out; side branches which are making a stronger growth than the others should be checked by shortening in, so as to maintain an evenly balanced head. Some varieties have an upright habit of growth and some make a slender, straggling growth. All need attention each year. In cutting back the last year's growth the top bud should be left on the side of the branch facing the direction in which the growth needs to be diverted. By this method there will be no difficulty in shaping the tree into any desired form.

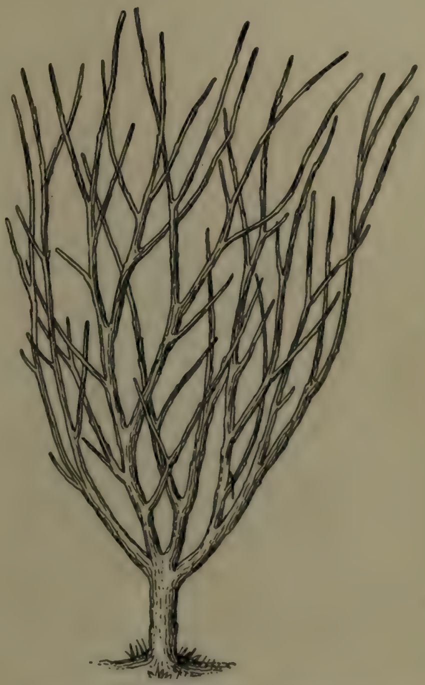


FIG. 5.—Vase or goblet form of top.

All pruning and training possible should be done while the trees are young and the growth of wood is tender. At such time the healing over is more rapid and complete, and the tree suffers less injury.

Old trees that have been neglected may be renewed by severe pruning, cutting back all the branches that are not in a healthy condition. This pruning will cause new, vigorous shoots to grow. The new growth will need to be cut back as occasion requires. By persistent pruning an entire new top may be formed in a few years.

When the removal of a large branch is necessary, the wound should be covered with grafting wax, paint, or some other substance that will prevent evaporation and keep the wood from checking and consequent decay.

FORM OF TOP.

In foreign countries the pear is trained into many forms by pruning, but in this country the forms followed in shaping the tree are mainly limited to three—vase, pyramidal, and intermediate.

Vase or goblet form.—The vase or goblet form, or some modification of it, prevails to a large extent in the Pacific coast region, where by long experience it has been found to be best suited to the conditions of that section of country. It is particularly suited to sections where blight is troublesome because of the ease with which the infected branches can ordinarily be cut out before the disease reaches the trunk of the tree. Growth into this form is promoted by cutting back the 1-year-old tree after it is transplanted from nursery to orchard to 12 to 15 inches from the ground, all limbs having been removed, leaving but a single stalk, as shown in figure 3. After the buds begin to grow, all but three or four should be rubbed off, leaving those that are intended for the top evenly distributed on all sides of the tree and several inches apart vertically. Subsequent pruning must be done each year by shortening back the new growth and thinning out with a view to shaping the tree, as shown in figure 5.

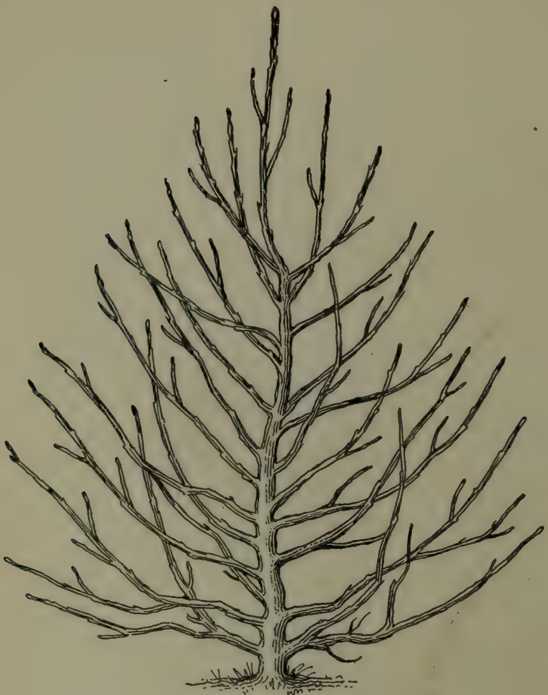


FIG. 6.—Pyramidal form of top.

Three or four main branches that were allowed to grow should be continued upward to form the framework of the tree, and all the pruning and training should be done with a view to forming an open head to admit sunlight and air to all branches of the tree. Shortening back of the annual growth is very essential, especially on dwarfs.

Pyramidal form.—The pyramidal form differs from the vase form in that the main leading shoot of the tree is allowed to maintain its upright growth and the side branches are shortened back so as to produce the shape of a pyramid, as shown in figure 6.

As in pruning for the vase form, the main stock of the 1-year-old tree should be cut back to 12 to 15 inches, but numerous branches are allowed to grow in order that the tree may assume the form shown in the figure.

Intermediate or natural form.—The intermediate form (fig. 7) is probably the best for training the pear. It is a compromise between the vase and the pyramidal forms and its outlines are not so conventional. The tree is allowed to grow more in accord with its natural habit, but it must be checked more or less in its growth so as to conform to the ideas of the planter. Different varieties of the pear vary greatly in their habits of growth. Some trees are upright and some are of a drooping habit. Both of these forms should be modified. Upright branches are shortened back and induced to spread out; and the limbs of the tree inclined to droop are encouraged to grow more nearly upright.

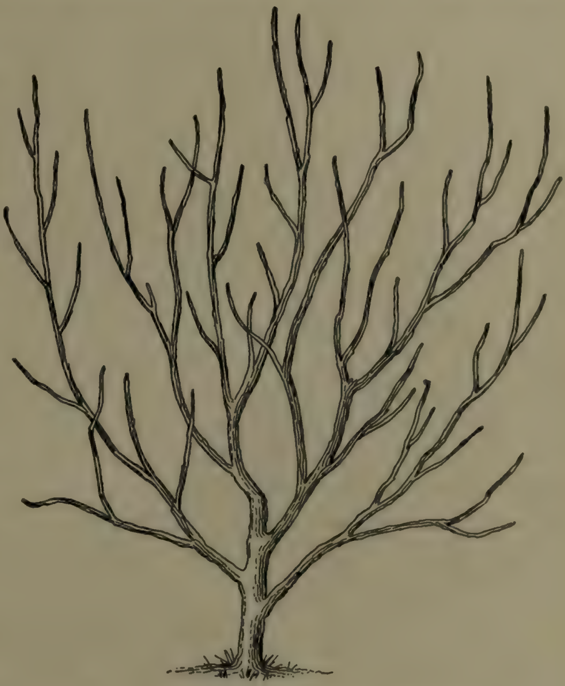


FIG. 7.—Intermediate or natural form of top.

HEIGHT OF TOP.

It is now conceded that low-topped trees are preferable to the old high-topped system of training, which was to train trees to 4 or 5 feet in height.

The objection to low-headed trees on account of the difficulty of cultivating the land has been overcome by practical experience. A careful teamster will do less damage to a low-headed tree than to one with a high top; with the improved implements now in use thorough tillage can be performed as well among low-headed trees as with higher ones. There is less danger from high winds with low heads; pruning and spraying can be performed with greater facility and the expense of gathering the fruit is greatly reduced. Another important advantage gained by low heads is the protection of the body of the tree from the hot sun causing what is known as sun scald, which is prevalent in some sections of the country.

PROTECTION FROM RODENTS.

Wherever mice and rabbits exist they are liable to do much damage to young fruit trees during the winter months, especially when the ground is covered with snow. Anything that affords protection to mice, such as grass, weeds, or leaves should be removed from around the trunks of the trees, leaving the ground bare. Mice will not work in such exposed places.

It is only when the natural food of the rabbit is cut off by being covered with snow that this destructive little animal is forced to resort to other means of subsistence by gnawing the bark of fruit trees. To prevent this pest from doing this damage many methods have been devised. Washes of various kinds have been used, but the most effective plan is to tie some material to the height of 2 feet or more around the body of the tree. Cornstalks cut to the desired length are the most available material for the farmer to use and serve the purpose very well. Building paper is very effective, and even old newspapers tied around the trees have been found to do good service while they last. All things considered, wire netting is perhaps the best and most effective material. Its first cost is somewhat greater, but in the long run it is cheaper. It is light and open, admitting air and sunlight freely, and affords no harbor for mice or insects. This netting or wire cloth is made of galvanized wire No. 22, ¼-inch mesh. It is made 24 to 36 inches in width and can be purchased at any hardware store at about $3 per roll of 100 linear feet for the 24-inch width. A 12-inch strip cut from this roll is sufficient to encircle a tree, thus making the cost of protection about 3 cents each.

DISEASES AND INSECT ENEMIES.[1]

PEAR BLIGHT.

Pear blight, also known as fire blight, is the most destructive and the most difficult to control of all diseases with which the pear is affected. All attempts to check its ravages by the ordinary methods of spraying with the different compounds have been of no avail. The conditions that are most favorable to the development of the disease are a moist, warm atmosphere when the tree is making its most rapid growth, generally in the month of June. In dry seasons when the trees make a slow, scanty growth blight seldom makes its appearance; hence the importance of avoiding too much nitrogenous manure which would stimulate the tree into a rapid succulent growth.

---

[1] For additional information relating to diseases and insect enemies of the pear the reader is referred to the following publications of the Department of Agriculture:

Cold Storage with Special Reference to the Pear and Peach. Bulletin 40, Bureau of Plant Industry. 1903.

Nomenclature of the Pear; a Catalogue-Index of the Known Varieties Referred to in American Publications from 1804 to 1907. Bulletin 126, Bureau of Plant Industry. 1908.

The Cause and Prevention of Pear Blight. Yearbook, U. S. Dept. of Agriculture, for 1895, pp. 295–300.

Commercial Pear Culture. Yearbook, U. S. Dept. of Agriculture for 1900, pp. 369–396.

In some sections of the country, as in the Middle West with its rich prairie soil, pear blight is much more prevalent than in the sections where the soil is not so rich in humus and the trees make a slower growth.

In some parts of this country, notably in New England, this disease is much less destructive than in other sections. Some varieties are less subject to attack; for example, Seckel, Kieffer, Garber, Le Conte, Angouleme, etc. No remedy has yet been discovered, but there are treatments that in a measure modify and mitigate the severity of the disease, and, as before stated, the checking of too rapid growth is one means of prevention, and by the proper use of the knife and saw the disease can be quarantined and its spread held in check. As soon as any blight appears on the young growth it should be severely cut back and the branches burned. Throughout the growing season the trees should be watched with the utmost vigilance and all signs of blight as they appear should be entirely removed. Symptoms of the disease can more readily be detected while the leaves are on the tree by observing their discoloration. The work of inspection, however, should not cease with the falling of the leaves. The search must continue through the winter to discover any trace of the disease that may have escaped notice of the observer during the growing season.

PEAR SCAB.

A fungus disease similar to if not the same as apple scab is easily controlled by spraying with Bordeaux mixture or the lime-sulphur preparation.

INSECTS.

The pear in common with other fruits is subject to the depredations of insects, among the more important of which are the codling moth and the San Jose scale.

The larva of the codling moth, which affects the apple to such an alarming extent, entailing a loss of millions of dollars, is also more or less injurious to the pear, though to a much less extent than to the apple.

Probably no other insect, if uncontrolled, is capable of doing greater damage to the fruit industry of this country than the San Jose scale. Nearly all kinds of deciduous fruit trees are more or less subject to its attacks. It multiplies and spreads with such great rapidity that unless controlled it is but a question of a short time until the tree is ruined and death follows. Nevertheless, this insect can be controlled at comparatively small cost, so that it is no longer to be regarded as an insurmountable obstacle to the growing of fruits. Experiments have been carried on by the entomologists of several State experiment stations and the United States Department of Agriculture with satisfactory results. The use of the lime-sulphur wash has come to be the generally accepted remedy.

For full information on the San Jose scale and its control, readers should apply to the Secretary of Agriculture, Washington, D. C., for Circular 124 of the Bureau of Entomology. The control of the codling moth on pears is fully treated in Bulletin 97, Part II, of the same Bureau.

THINNING THE FRUIT.

In order to produce a high grade of fruit it becomes necessary to thin the overloaded trees by taking off all deformed inferior fruit, insect-infested specimens, as well as the perfect fruits wherever they are nearer than 4 to 6 inches on the limb; this thinning is done at the proper time, customarily after what is known as the June drop. By this thinning the remaining fruit grows larger and at gathering time it will be found that the quantity in bulk has not been reduced, but in fact there will be more bushels of fruit of first grade on the tree than if all the fruit had remained. The fruit will be increased in size and quality and the tree will be relieved of a corresponding burden and consequently be better able to bear a crop of fruit the following year.

The proper time for thinning depends somewhat upon the season, usually about the last of June or early in July. The amount of fruit to be removed will depend largely upon the judgment of the grower and the quantity of fruit set. The cost of thinning will scarcely be any more than the extra work occasioned by the picking and grading of so much inferior fruit when the whole crop is allowed to grow without thinning.

GATHERING THE FRUIT.

A knowledge as to the best time for gathering pears can be most readily obtained from careful observation and experience. No precise and invariable rule can be given. Some growers gather the fruit as soon as the seeds turn brown. While this condition may be safe in a general way, and even necessary for shipping to a distant market, it does not afford the highest excellence of fruit for dessert purposes. Some varieties, such as Clapp Favorite, require picking some time before they are fully ripe in order to prevent rotting at the core. This rule applies more or less to most of the early varieties.

As a general rule it is safe to gather the fruit whenever the stem will easily part from the limb by twisting or turning the fruit from the natural position with thumb and forefinger.

All fruit should be gathered with the stems unbroken, carefully avoiding bruising or breaking the skin.

As pears of any one variety do not all ripen at the same time several pickings at intervals will be necessary. This is no disadvantage to the grower, as it will aid him in disposing of the crop without loss.

Winter sorts should be left on the tree as late in autumn as it is safe to leave them without freezing.

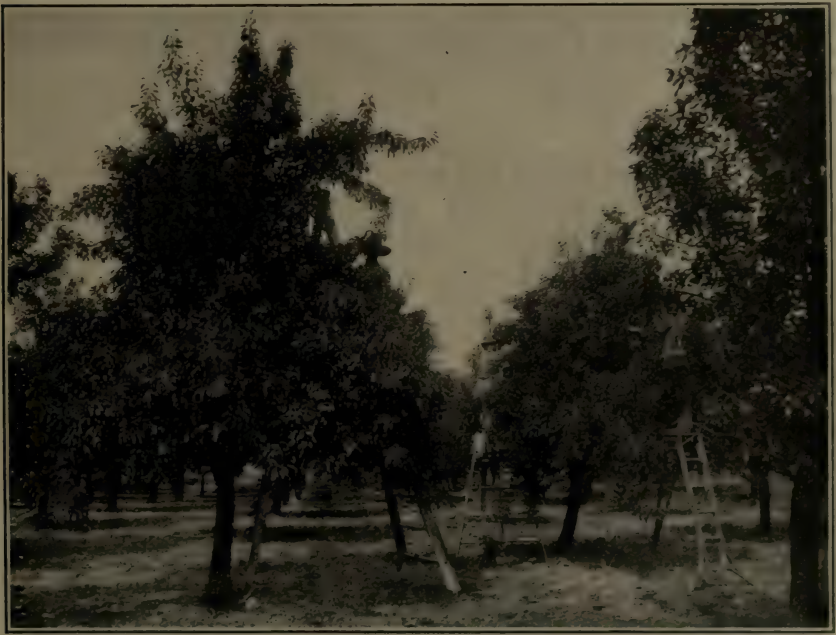


FIG. 8.—Bartlett pear orchard, showing manner of picking the fruit by the use of ladders.

Some form of ladder is absolutely essential in gathering pears, especially for standard trees after they have attained a considerable size. Nearly all of the fruit on dwarf trees can be picked from the ground if the trees have been properly pruned. A three-legged step-ladder with a wide spread of legs at the bottom is probably the most serviceable form, all things considered. Its three legs afford easy adjustment to uneven ground. (See fig. 8, right-hand corner.)

A splint half-bushel basket, cloth lined and with adjustable bale, is best for gathering the fruit.

SORTING AND GRADING THE FRUIT.

A crop of fruit of any kind will bring the grower more money when properly sorted and sold by grades as firsts, seconds, and culls. The first grade should consist of such as are of average uniform size, well formed, clean in appearance, sound, and free from blemish and insect injuries. Seconds are the same as first grade with the exception of being smaller in size and irregular in form.

Culls, or the third grade, may include all that are rejected from the first and second grades, except those suitable for canning, preserving, or evaporating.

PACKAGES.

The packages used for marketing pears vary according to the section of country where the fruit is grown. In California boxes each having a capacity of about 40 pounds are universally used. The inside measurements of these boxes are as follows: Length, 18½ inches; width, 11¾ inches; depth, 8½ inches. In New England and New York State a keg holding about 1 bushel is largely used. In New York and Michigan a special pear barrel, having a capacity 1 peck less than the standard apple barrel, is largely used. In the States where the Kieffer and Le Conte are largely grown the common apple barrel is used. The half-bushel box, neatly made, is better adapted for the choice varieties of pears. A box of this size or even smaller is better suited for the retail trade than a larger one. Fancy fruit wrapped in paper and with fancy labels on the package will command fancy prices, according to the old saying, "the best articles are always put up in small packages." For convenience in handling and shipping, these packages can be crated at very slight expense and they reach a home or foreign market in perfect safety. It pays the grower handsomely to carefully pick, grade, and pack his fruit in the very best manner possible. A few cents paid in ornamenting and branding packages is money well spent.

THE FRUIT ROOM.

An apartment especially adapted for use as a fruit room is needed on every farm where fruit is grown even in such quantity as to be used for family purposes only. It should be so constructed as to afford protection from heat in summer and from frost in winter and sufficiently ventilated to maintain purity of air and freedom from odors.

Shallow bins not more than 4 inches deep may be constructed along its walls, one above another and far enough apart to afford ample space for placing the fruit and for its subsequent handling.

Strict cleanliness should be maintained in every detail of handling. Care in this respect is essential to the preservation of the delicate aroma that characterizes many kinds of the pear and to the retention of the exquisite flavor so much desired. In no case should vegetables of any kind be stored in the same room with the fruit.

DISPOSING OF THE CROP.

If for home use or home market, the fruit as soon as picked should be carried to the fruit room, carefully sorted and graded, and placed not more than two or three layers deep in bins. While undergoing the sweating process in the bins the fruit should be covered with paper to exclude air and light and should be examined often for the change from the hard, green condition to the yellow, mellow state. Fruit showing this change should be sorted out for use or for market. If to be sent to market it should be carefully packed in small, paper-lined baskets or shallow boxes and shipped at once.

Each package should be branded with the name of the variety and the name of the grower. Choice fruit in small packages finds ready sale at high prices for immediate family use.

Winter varieties are stored in the fruit room in the manner described and keep well if held at as low a temperature as possible without freezing. When desired for use or market during the winter months the pears may be brought into a moderately warm room to mellow or ripen. The fruit must be protected from light and air or it will become wilted and tough and would also lose its excellent flavor.

The practice of wrapping each fruit in paper after the method adopted with the lemon and orange as soon as picked and sorted affords better results with most classes of fruit for shipment.

ABRIDGED DESCRIPTIONS OF SELECT VARIETIES OF PEARS.

The main object of the brief descriptions that follow is to direct the attention of the prospective grower to some of the most desirable varieties of pears which in the experience of the writer have proved to be the most valuable for commercial and family use and, also, to give some idea of the quality of the fruit to serve as a guide in the selection of varieties for planting. The time of ripening of varieties depends upon the latitude, elevation, and local conditions where they are grown; therefore, dates can only be given approximately. The name of each variety herein used is the one adopted by the American Pomological Society, which is the recognized authority on nomenclature. Synonyms when given are shown in parentheses:

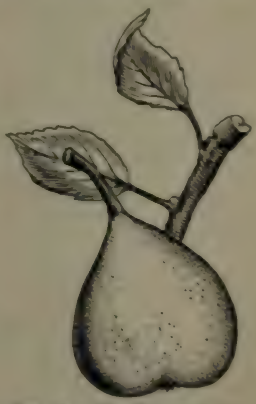


FIG. 9.—Bloodgood pear.

BLOODGOOD.

Origin, Long Island. Medium size, turbinate, inclining to obovate (fig. 9); skin yellow, with russet dots and network markings; calyx strong, open, set almost without depression; stalk obliquely inserted without depression, short, fleshy at base. Flesh yellowish white, buttery, melting, with a rich, sugary, aromatic flavor; very good. Ripens in midsummer; like most early pears it is better if picked early and ripened indoors. A most delicious pear, deserving a place in every fruit garden, but not attractive for market.

CLAPP FAVORITE.

Origin, Massachusetts. Fruit large, obovate, slightly obtuse pyriform (fig. 10); pale yellow, marbled and splashed with crimson on exposed side, thickly sprinkled with brown dots; stalk an inch long, a little inclined, stout, somewhat fleshy; calyx partly closed. Flesh white, fine grained, juicy, melting, buttery, rich, sweet, vinous, slightly perfumed. Ripens about 10 days before Bartlett. Tree upright, spreading; very productive. Should be picked before fully ripe.

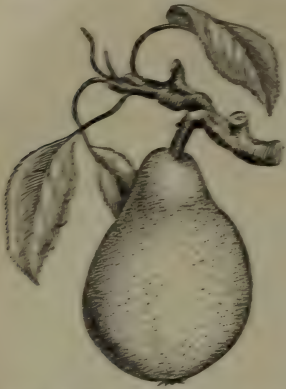


Fig. 10.—Clapp Favorite pear.

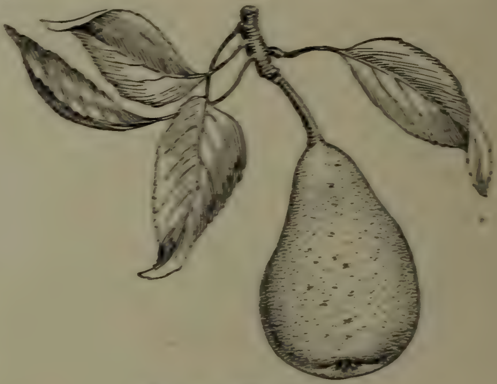


Fig. 11.—Giffard pear.

GIFFARD.

Origin, France. Fruit medium size, pyriform, tapering to the stem, which is rather long (fig. 11); skin greenish yellow, marbled with red on exposed side; calyx closed. Flesh white, melting, juicy, vinous flavor; very good. Ripens in August. Should be gathered before fully ripe.

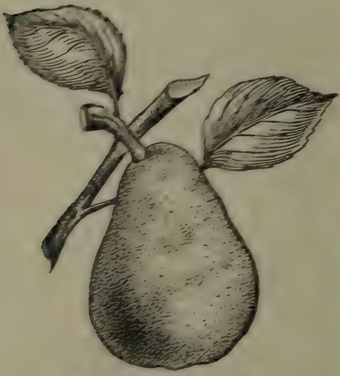


Fig. 12.—Bartlett pear.

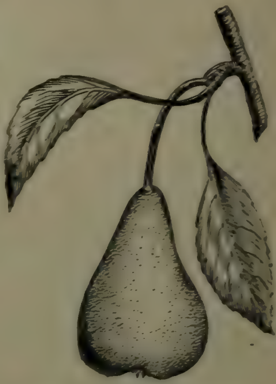


Fig. 13.—Rostiezer pear.

BARTLETT.

Origin, England. Large, obtuse pyriform; surface uneven (fig. 12); skin thin, bright clear yellow, with blush on the sunny side on exposed specimens, sometimes a little russet. Flesh white, buttery, juicy, highly perfumed, vinous flavor. Ripens in midsummer. It is one of the few choice varieties that succeed over a wide range of country and is more largely grown for commercial purposes than any other variety. Excellent for canning, preserving, and evaporating.

ROSTIEZER.

Origin, Germany. Medium size, oblong pyriform (fig. 13); color dull yellowish, mixed with reddish brown; stem long, slender, curved, inserted with slight depression; calyx open, persistent; basin small and corrugated. Flesh juicy, slightly buttery, melting, sugary, vinous, aromatic, perfumed; quality best of its season, August and September. Tree an early and profuse bearer.

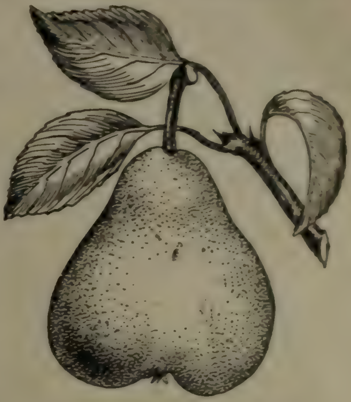


Fig. 14.—Brandywine pear.

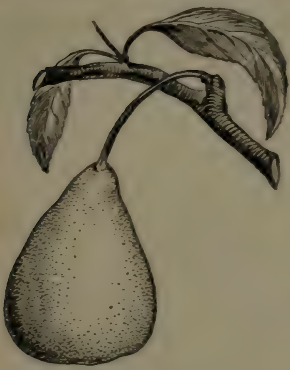


Fig. 15.—Tyson pear.

BRANDYWINE.

Origin, Pennsylvania. Size medium, pyriform (fig. 14); skin dull yellowish green, slightly russeted, with a warm cheek on sunny side; stalk fleshy at its junction with the fruit; calyx open. Flesh white, juicy, melting, sugary, vinous, aromatic; late summer.

TYSON.

Origin, Pennsylvania. Medium or below in size; conic pyriform (fig. 15); skin clear deep yellow, with a fine crimson cheek and numerous brown dots; stem long and curved, inserted with a fleshy ring or lip; calyx closed. Flesh juicy, very sweet, melting, aromatic; late summer. Tree vigorous, upright grower, very productive. An excellent variety both in tree and fruit.

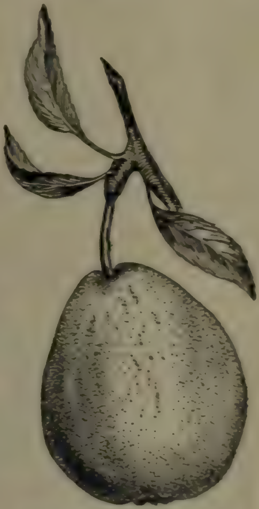


Fig. 16.—Flemish pear.

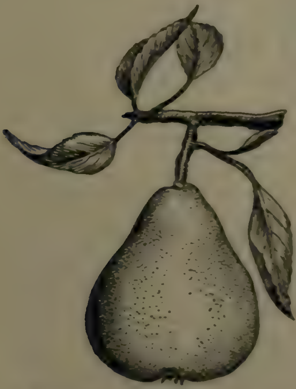


Fig. 17.—Lucrative pear.

FLEMISH (FLEMISH BEAUTY).

Origin, Belgium. Fruit large, obovate, obtuse pyriform (fig. 16); surface yellow, covered with patches of light russet, becoming reddish brown on the sunny side; stalk 1 to 1½ inches long; calyx shore, open. Flesh yellowish white, juicy, melting, sweet, rich, with a slightly musky flavor; very good; September.

LUCRATIVE (BELLE LUCRATIVE).

Flemish origin. Medium size; variable in form from globular to obtuse pyriform (fig. 17); stalk 1½ inches long, often fleshy, oblique; cavity small and narrow; calyx short, open. Flesh juicy, melting, rich, sugary, delicious; last of September.

BOSC.

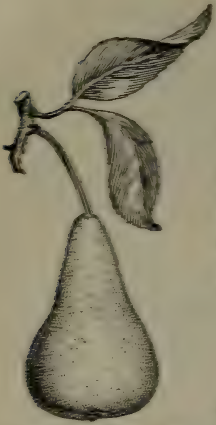


Fig. 18.—Bosc pear.

Origin, Belgium. Large, decidedly pyriform; neck long, tapering to the stem, which is 1 to 2 inches long and rather slender (fig. 18); color dark yellow, covered with dull cinnamon russet with dots or streaks, sometimes with a tinge of red. Flesh white, very buttery, melting, rich, perfumed. Tree vigorous, a regular bearer; fruit evenly distributed over the tree and always of good size. A valuable market variety; midautumn.

LOUISE (LOUISE BONNE DE JERSEY).

Origin, France. Fruit large, oblong pyriform (fig. 19); greenish yellow, overspread with brownish red, becoming brighter on the sunny side; stalk long, often fleshy at insertion; calyx open. Flesh yellowish white, very juicy, buttery, melting, rich, slightly subacid; good to very good; midautumn. Tree very productive; excellent on quince stock.

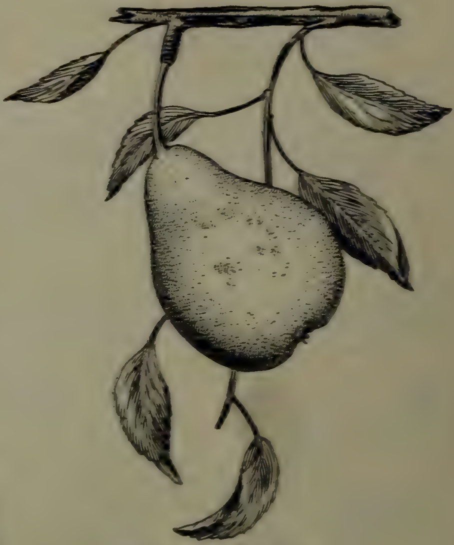


Fig. 19.—Louise pear.

WHITE DOYENNE.

Origin, France. Medium to large, obovate, obtuse (fig. 20); surface pale yellow, often a faint blush; stalk 1 inch long; calyx small, basin shallow. Flesh fine grained, melting, buttery, high flavored, delicious. Better adapted to the rich soils of the West. Last of September; if picked before fully ripe, will keep until December. In some sections it is subject to cracking and scab.

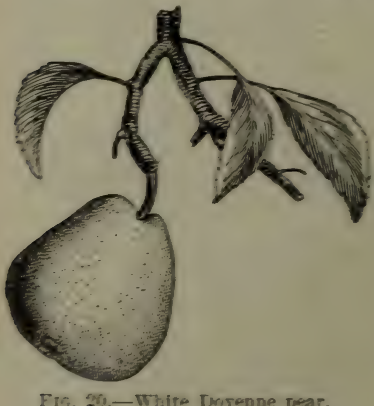


Fig. 20.—White Doyenne pear.

SECKEL.

Origin, Pennsylvania. Fruit small, roundish, obovate (fig. 21); surface yellowish brown, with a lively russet-red cheek; stalk one-half to three-fourths of an inch long: calyx small, in a basin scarcely sunken. Flesh fine grained, sweet, very juicy, melting, buttery: considered to be the acme of perfection among pears. End of August to last of October.

SHELDON.

Origin, New York. Medium or large, roundish, obtuse obovate (fig. 22): skin greenish yellow, covered with thin russet, a little brownish crimson with russet dots on exposed side: stalk short, stout: cavity deep: calyx open. Flesh whitish, sweet, very juicy, melting, vinous, texture rather coarse: very good: October. Tree vigorous: it requires double working on quince.

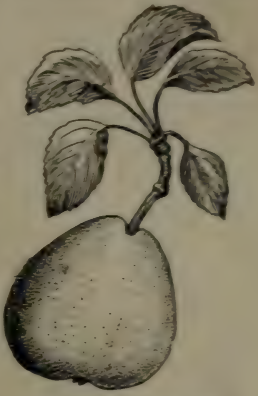


Fig. 21.—Seckel pear.

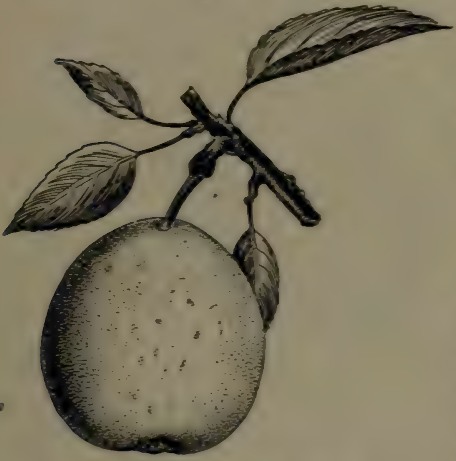


Fig. 22.—Sheldon pear.

ANJOU.

Origin, France. Large, obtuse pyriform; stem short, thick, fleshy (fig. 23); skin greenish yellow, sometimes shaded with dull crimson and sprinkled thickly with brown dots; calyx very small, open, stiff, in a small basin surrounded with russet. Flesh whitish, melting, juicy, brisk, vinous; late autumn to early winter. Tree vigorous, open round head: fruit evenly distributed and of uniform size. An excellent market variety.

KIEFFER.

Origin, Pennsylvania. Medium to large, oval pyriform (fig. 24); rich golden yellow sprinkled with numerous dots, sometimes beautifully shaded with red on sunny side. Flesh rather coarse, juicy, varying from good to poor in quality; valuable for canning and preserving; October to December. Tree vigorous and very productive. Adapted to a wide range of country.

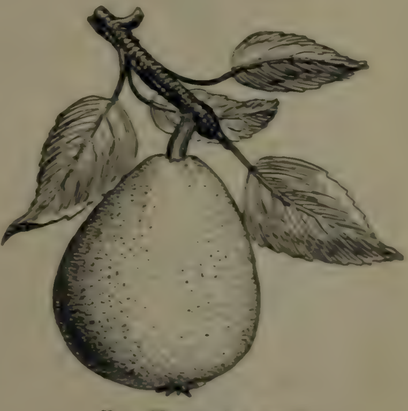


Fig. 23.—Anjou pear.

ANGOULEME (DUCHESSE D'ANGOULEME).

Origin, France. Large to very large, oblong obovate (fig. 25); surface uneven; dull greenish yellow, with more or less of russet spots; stalk 1 to 1½ inches long, stout; cavity deep, often wide; calyx small, basin uneven. Flesh white, melting, buttery, juicy; quality excellent when well grown; best on quince stock. Ripens in midautumn. Tree a vigorous grower. very prolific. and profitable: a very popular variety for commercial purposes.

COMICE.

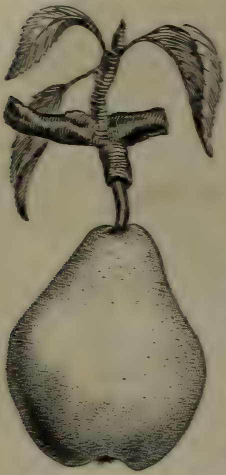


FIG. 24.—Kieffer pear.

Origin. France. Fruit large. varying from roundish to obtuse pyriform (fig. 26): greenish yellow. clear yellow at maturity. some russet shaded with crimson on sunny side; stalk short and stout. inclined and set in a shallow cavity; calyx small, open, in a deep. uneven basin. Flesh white. fine grained. sweet. rich. slightly aromatic flavor: October and November.

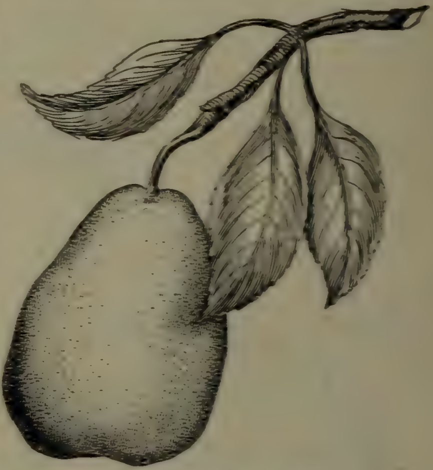


FIG. 25.—Angouleme pear.

DANAS HOVEY.

Origin, Massachusetts. Rather small. obovate. obtuse pyriform (fig. 27); pale yellow, with patches of cinnamon russet and sprinkled with brown dots: stalk rather short. slightly curved. set in a shallow cavity: calyx open. basin small. uneven. slightly russeted. Flesh yellowish. juicy. rich. sugary. aromatic: one of the most delicious pears grown; early winter.

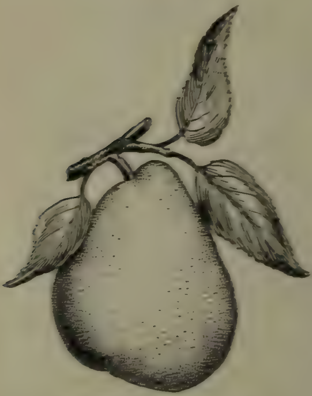


FIG. 26.—Comice pear.

LAWRENCE.

Origin. Long Island. Fruit medium or above in size, obovate. obtuse pyriform (fig. 28). somewhat uneven: color lemon yellow. with traces of russet and numerous brown dots: stalk of medium length, rather stout, set in an irregular russeted cavity; calyx open. basin broad, shallow, uneven. and thinly russeted. Flesh whitish, juicy. buttery. sweet. aromatic; very good to best; December.

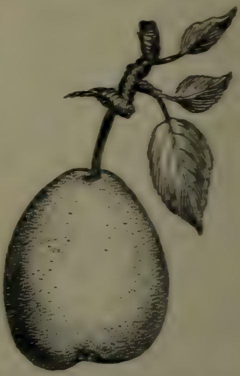


FIG. 27.—Danas Hovey pear.

WINTER NELIS.

Flemish origin. Fruit medium. roundish obovate. somewhat pyriform (fig. 29): stalk 1¼ inches long: calyx open. basin shallow. ribbed. Flesh yellowish. fine grained buttery. melting. sweet. rich. aromatic flavor. Early winter; one of the best of its season.

EASTER BEURRE.

Origin. France. Fruit large, roundish obovate, obtuse (fig. 30); stalk rather short, stout, in an abruptly sunken cavity; calyx small, closed, slightly sunken; skin yellowish green, with many russet dots and reddish-brown cheek. Flesh white, fine grained, buttery, rich, sweet, and juicy; January to March. Does not mature if planted too far north.

SUMMARY.

(1) A gentle eastern or northeastern slope as a rule is preferable for an orchard site, but this feature may vary according to conditions.

(2) Soils such as are found in timbered regions are best suited for the pear. Stimulating fertilizers are conducive to pear blight; care should be taken to guard against the disease.

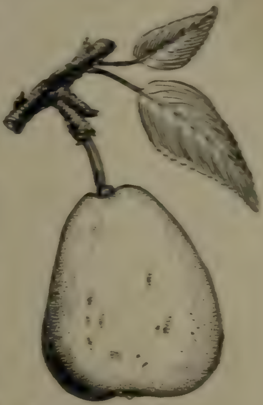


FIG. 28.—Lawrence pear.

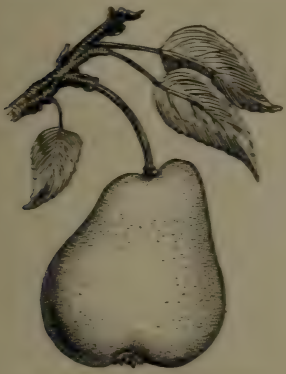


FIG. 29.—Winter Nelis pear.

(3) One-year-old trees with well-developed root systems are considered best, and at the time of planting they should be cut back to the height at which the main branches for the future top are to be formed. All broken and bruised roots should be cut back to sound tissue. For easy planting, open a deep furrow with a 2-horse plow along the line where the rows are to be made and cross-check at the distance apart at which the trees are to stand. At the crosses level off the bottom of the furrow to receive the tree with its roots in their natural position; fill in among the roots and trample down the soil, leaning the tree slightly to the southwest.

(4) Prune each year while the tree is in a dormant state; remove interfering cross branches and thin out where too densely grown; balance the top so as to afford free air circulation and admit sunlight to all parts of the tree.

(5) Picking, sorting, and packing the fruit should be done carefully so as to avoid bruising or puncturing the skin.

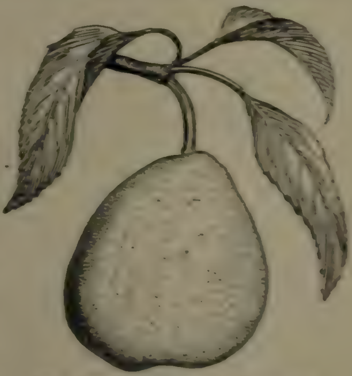


FIG. 30.—Easter Beurre pear.

(6) Summer and autumn varieties, if for market, unless placed in cold storage where they may be held for a while during a glut in the market, require immediate attention and disposition.

Issued March 8, 1912.

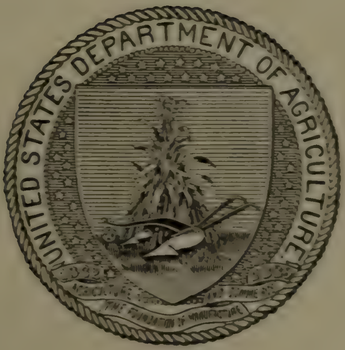
U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 483.

THE THORNLESS PRICKLY PEARS.

BY

DAVID GRIFFITHS,
Agriculturist, Farm-Management Investigations,
Bureau of Plant Industry.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

U. S. SUPT. OF DOCUMENTS

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., December 28, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "The Thornless Prickly Pears," by Dr. David Griffiths, which has been submitted for publication by Prof. W. J. Spillman, Agriculturist in Charge of Farm-Management Investigations.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction. 5
Geographic distribution of thornless prickly pears. 6
Moisture requirements. 8
Temperature requirements. 8
Yields. 9
Composition and value of the forage. 10
Soil adaptations and requirements. 11
Ideal conditions for growth. 12
Propagation. 12
Planting. 14
Cultivation. 16
Time of harvesting. 16
Stability of the spineless character. 17
Transportation of prickly pears. 18
How to obtain thornless prickly pears. 19
Fruit and forage varieties of prickly pears. 20
Botanical status of thornless prickly pears. 20

ILLUSTRATIONS.

Page.
FIG. 1. A very rapid-growing species of prickly pear with few spines, from Mexico. 5
2. One of the best spineless species of prickly pear, a rapid grower and bearing edible fruit, from the Mediterranean region of Europe. 6
3. Propagating plats of prickly pears at the Plant-Introduction Garden, Chico, Cal., immediately after the crop was harvested for distribution in April, 1911. 13
4. A view of the plats of prickly pears shown in figure 3, before harvesting. 15

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

B. P. I.—718.

THE THORNLESS PRICKLY PEARS.

INTRODUCTION.

The terms "thornless" and "spineless" prickly pears as used in this paper are intended to designate those large rapid-growing species of the botanical genus Opuntia which do not produce so many spines and spicules that they can not safely be fed to live stock. (Figs. 1 and 2.) No account is taken here of numerous small spineless forms,[1] some of which will withstand a great deal of cold. They are of such slow growth and are so small at best as to be of no economic value. Even some species[2] which are spineless and attain a good growth are not considered. They, as well as the smaller ones of the first-mentioned group, are excluded because they are armed with

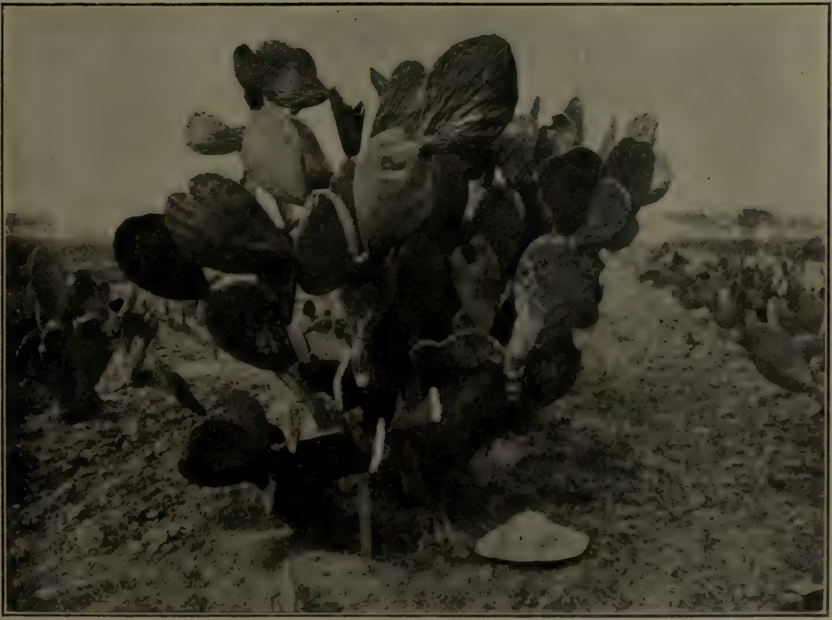


Fig. 1.—A very rapid-growing species of prickly pear with few spines, from Mexico.

---

[1] *Opuntia vulgaris, O. macrorhiza*, and *O. allairei*.

[2] *Opuntia subarmata*, forms of *O. cacanapa* and *O. ellisii*.

many spicules and have not as yet given satisfactory results when used as forage. The second group is practically without spicules but of slow growth.

It must be remembered that the words "thornless" and "spineless" are only relative terms. There is no species of the prickly pear entirely without an annoying needle-like armature. The different species of the genus Opuntia have two forms of spines designated in descriptive works as "spines" and "spicules." The plants discussed here are nearly free from spines. They bear spicules, which are simply small, fragile, and easily detached spines, in varying number, but not enough to prohibit their being fed to cattle without previous preparation.

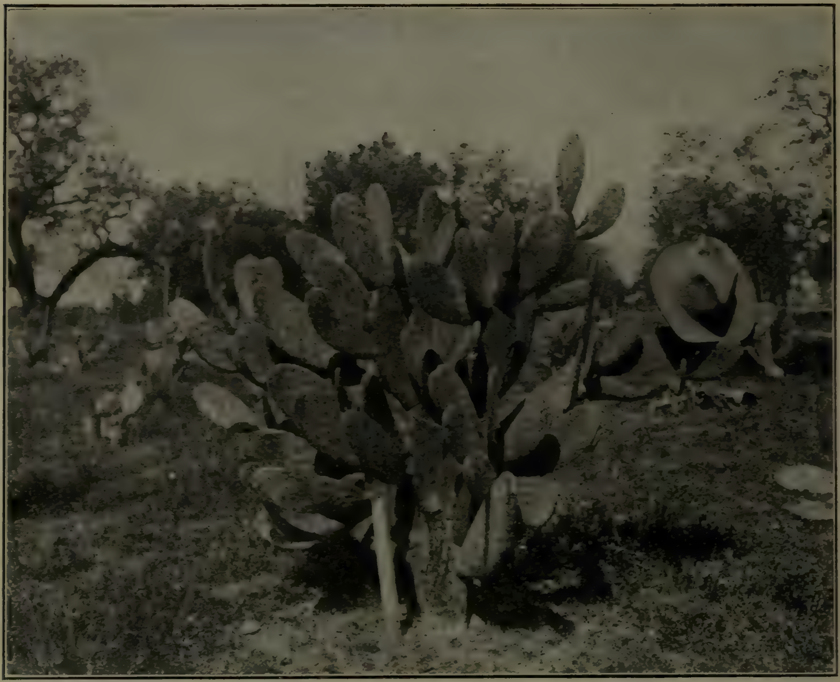


FIG. 2.—One of the best spineless species of prickly pear, a rapid grower and bearing edible fruit, from the Mediterranean region of Europe.

GEOGRAPHIC DISTRIBUTION OF THORNLESS PRICKLY PEARS.

At the present time there are spineless forms of prickly pear scattered over most of the warmer regions of the globe. To regions which have truly moist, tropical climates, such species as the cochineal cactus (*Nopalea cochinelifera*) appear to be the best adapted. To the warm temperate regions and to the regions of periodical rainfall various species of the genus Opuntia are better suited. Spineless forms are most abundant in the mediterranean regions of the three continents. They are common but never extensively cultivated in Mexico. Frequently they are met with in the tropical and subtropical islands, while similar forms are found in South Africa, Australia, and South America. In the United States an occasional plant is found along the Florida coast. In California they are more or less common in parks, where they were introduced many years ago. Recently they have been distributed by the Department of Agriculture on the immediate coast of the Gulf of Mexico and in southwestern Arizona and southern and western California.

In 1909 the Department of Agriculture published a preliminary map[1] indicating, in a general way, the regions best adapted to the culture of these plants. Subsequent experience has proved that the area shown in that publication was rather too large.

Prickly pears may be grown along the coast of California as far north as Humboldt County, and some of the *Opuntia robusta* group, which although large are rather slow growers, may be extended into Del Norte County. In the interior valleys the limit of their endurance appears to be reached in Butte County. At Chico, Cal., they are injured about every third or fourth year and occasionally look as though nearly killed by low temperatures; by leaving the plants alone, however, they have recovered with practically no loss. In the past they have suffered to a somewhat greater degree in portions of the San Joaquin Valley. This applies to the large, rapid-growing, Indian fig group. The cochineal pear is much less hardy and will not live at Chico without protection.

In southern Texas the area where thornless prickly pears may be grown, outlined in the map referred to, must be greatly restricted. There is very good evidence that the plants will not thrive permanently north of the Texas Mexican Railway. During the winter of 1910–11 they were cut to the ground at Falfurrias, and some were injured slightly as far south as the northern part of Cameron County. Experimental cultivation near Corpus Christi indicates that even on the immediate coast their success is questioned. It is evident that prickly pears will not succeed along the Gulf coast of the Southern States except in Florida. It has been demonstrated that in the interior of that State they will not succeed, even though the temperatures are favorable, but recent reports indicate that they may do well in restricted portions of the coastal region.

In Arizona the plants may be grown with irrigation from the Colorado River eastward as far as Tucson upon the valley and desert mesa lands.

---

[1] Bulletin 140, Bureau of Plant Industry, U. S. Department of Agriculture, entitled "The 'Spineless' Prickly Pears," p. 15.

It will be seen that the culture of spineless prickly pears in the United States is limited to the coast and interior valleys of California, the extreme southern portion of the Rio Grande Valley in Texas, the warmer portions of southern Arizona, and possibly the coastal region of southern Florida. Their growth upon the elevated regions of California and Arizona is soon limited by the increasingly low temperatures, and they will not endure the winter temperatures of any locality in New Mexico.

MOISTURE REQUIREMENTS.

It is as difficult to place the limit of drought endurance for the thornless prickly pears as for any other cultivated crop. The prevalent notion that these plants need no water is erroneous and should be given no credence whatever. Neither are the plants as resistant to drought as many of the spiny natives.

The desert mesas of Arizona, with their rainfall of 6 to 11 inches, are altogether too dry for the growth of these plants, even with the best of cultivation. In the upper foothills of the Santa Rita Mountains, at an elevation of about 4,000 feet, where the rainfall is 15 to 18 inches, the plants will thrive when protected from the inroads of rodents, but they make only a moderate growth. With good cultivation, at Chico, Cal., the winter moisture is prolonged sufficiently into the dry summer to enable the plants to grow vigorously from April to October with no additional water. It is to be remembered that these plants are surface feeders and do not draw vigorously upon the lower layers of subsoil for their moisture. In southern Texas they never appear to suffer from drought under even moderate cultural conditions, although no rain may fall for four or five hot months.

The question is often asked whether one can afford to grow spineless prickly pears if he has to irrigate them. This question can be answered only by the grower, as it depends upon the use to be made of the crop. It can be grown upon possibly one-third of the water required to grow alfalfa in most situations, and for this reason, if for no other, it may be profitable. On the other hand, if one needs succulent feed at a time when other crops are dry and he can grow prickly pears for that purpose, they can be made decidedly profitable.

TEMPERATURE REQUIREMENTS.

Like all other perennials it is impossible to state definitely what degree of temperature the plants of thornless prickly pears will stand or at what temperature they will be killed. So much depends upon surrounding conditions and circumstances that to predict within five degrees the temperature which they will endure under all circumstances is scarcely possible. The condition of the plants at the time of a freeze and the duration of the cold weather are most important considerations. In a region like southern Texas, where good growing weather may be followed within a few hours by a temperature of 20° F., more injury will be done than by the same freeze when the plants are dormant. Much also depends upon the conditions of the weather following the freeze. The blanket of fog that commonly obtains in the interior valleys of California during and following a cold season counteracts the effect of temporary low temperature to a remarkable degree.

Under average conditions a temperature of 20° F., if continued for any length of time, may be taken as fatal to these plants. They have been injured a little by this temperature in extreme southern Texas. They have suffered at the same temperature in the Sacramento Valley of California, but have recovered with little loss. At that time minimum temperatures of 22°, 21°, and 20° F. were experienced upon three successive nights, and freezing weather continued during the greater part of the three-day period. Under these conditions the plants were thought for a time to be practically dead to the ground, but after the advent of warm growing weather they recovered almost entirely. There was a loss of only about 1 per cent of the stock. If they had been handled, however, before the warm growing weather set in there would have been a heavy loss. Roughly speaking, it is believed that a minimum of 20° F. marks the limit of the endurance of these plants.

YIELDS.

No one in this country, so far as known, has much accurate information regarding the yields which the thornless prickly pears will make. They have not been planted extensively enough nor for a long enough time so that anyone is justified in making a general statement concerning this point. At Chico, Cal., where the stock of the Department of Agriculture is grown, no accurate measurements have been made. It can only be stated in a general way that the yield is satisfactory and that it is somewhere between 20 and 25 tons to the acre per annum. This, it must be remembered, is with expert cultivation and the maintenance of a perfect stand. The plantation has been carefully cultivated. All weeds have been kept down during the growing season and a good tilth maintained during the summer. Once or twice each year the whole plantation has been gone over and missing plants replaced.

A yield of 20 to 25 tons to the acre pays well, especially when other characteristics of the crop are taken into consideration. Such a yield means sufficient roughage for one cow from one acre without irrigation.

COMPOSITION AND VALUE OF THE FORAGE.

At various times attempts have been made to prepare commercial foodstuffs and silage from the prickly pear. It is a natural silage in that it can be gathered in the green, succulent stage at any time of the year. It is not, however, well adapted to drying. It parts with its water with extreme difficulty and contains such a large quantity that it is questionable whether an attempt to make it into dry fodder would be profitable. Again, even when the difficulty of drying is disregarded there is a still more potent objection in the fact that the dried product is not so palatable to stock, probably on account of the large quantity of mineral matters present, as demonstrated by the large quantity of ash residue when the plant is burned.

Viewed from any angle it would appear that the spineless prickly pear can be most advantageously and economically fed in the green, fresh state. In this condition the feed is to be compared most closely with root crops and immature, green corn fodder, and it should be fed in much the same manner. Being bulky and containing so much water, the feed will never be transported far, but will be grown close by, so that either the cattle can be turned on to it to graze or the haul to the feeding lot will be short. Its high water content, together wih the accompanying high average salt content, makes it a laxative feed when eaten in large quantity.

In this country no feeding tests with spineless prickly pears of long enough duration and varied enough in character to warrant any definite conclusions have been conducted, although extensive investigations of the spiny natives of southern Texas have been made. It is probably safe to substitute results obtained by practical feeders and scientific investigators with the spiny prickly pears for the spineless ones and to make calculations accordingly.

Although practical dairymen have used the native prickly pear successfully for months at a time, with almost no other roughage, it is more than probable that the best results could be secured by using some dry roughage in connection with it—feeding the prickly pear in a manner comparable to silage as commonly employed, i. e., as a part of the roughage in a dairy ration. This conclusion is reached upon both chemical grounds and the experience of some of the best posted feeders. On the other hand, some of the best herds in southern Texas have thrived on a continuous roughage ration of prickly pears and have kept in the best of condition with a rather heavy concentrated ration of cottonseed meal and rice bran. In one instance a herd of 80 to 100 cows had no other roughage for nearly two years. No inconvenience was apparent and the milk flow was good. Although the feed has a tendency to scour, it was considered by the dairymen that no injury resulted from this cause.

Many chemical analyses of the spineless prickly pears have been made, but nearly all lack very essential data. Usually it is impossible to tell exactly what forms were analyzed and there is seldom any idea given as to the portion of the plant used in the analysis. It is more than probable that it will be found, as in the spiny species, that old, woody stumps of three or more years' growth are preferred in feeding to the youngest, more succulent joints. Field experience indicates that cattle prefer the more mature joints. Prof. R. F. Hare, who has done more work on the chemistry of cacti than anyone else, has analyzed [1] a form with few spines which is closely related to this spineless group, and his results can be accepted until more work is done. Two analyses were made from cultivated plants grown at Laredo, Tex. Sample No. 7577 contained one joint each of 1, 2, and 3 year old growth. Sample 7519 contained one joint each of 2, 4, and 5 year old growths.

Table I.—*Chemical composition of two samples of a practically thornless form of prickly pear grown at Laredo, Tex.*

Constituent.	Green.		Air dry.	
	7519.	7577.	7519.	7577.
Water	81.16	92.25	5.18	8.12
Ash	4.29	1.75	21.65	20.80
Crude protein	1.32	.63	6.68	7.53
Crude fat	.28	.16	1.40	1.85
Nitrogen—free extract	8.88	4.02	44.56	47.60
Crude fiber	4.07	1.19	20.53	14 10

There have been few direct comparisons made between this and other feeds. One conducted at San Antonio, Tex., some years ago indicated that 6 tons of green, succulent prickly pear of a native spiny form is equal to 1 ton of good sorghum hay.

The value of the spiny native is very similar to that of the spineless prickly pear, and in the absence of direct tests we are justified in substituting these results when considering thornless varieties. There is probably little difference in the chemical composition of the two types, and the analyses given will indicate as much concerning the actual feeding value of the spineless varieties as they do with respect to the species analyzed. Indeed, in the cultivation of the prickly pear the most important point to be considered is rapidity of growth. The composition of the rapid-growing varieties is so similar that it will not be profitable at present seriously to consider it.

SOIL ADAPTATIONS AND REQUIREMENTS.

The mistake should not be made of expecting that the spineless prickly pear will grow anywhere and on any kind of soil. If well cared for and if it receives a suitable supply of water and good drainage it will thrive on almost any soil if the temperatures do not go too low. However, the plants make the best growth on the best soils, like any other crop. This is particularly noticeable in any native prickly-pear country; the best crop is on the best soils. This fact has been noted very emphatically by Prof. Maiden in his discussions of the regions of Australia infested with prickly pears.

---

[1] Bulletin 60, New Mexico College of Agriculture and Mechanic Arts, 1906, p. 73.

IDEAL CONDITIONS FOR GROWTH.

If the temperature never fell below 25° F. southern Texas would be an ideal region for the spineless prickly pears, and the cultivation of this crop would be exceedingly profitable. For its best development there is required good soil, irregular, comparatively heavy rainfalls, and a high minimum temperature.

It will be readily seen that there are indeed few regions upon the mainland of the United States where conditions are ideal for the cultivation of the spineless prickly pear. The temperature falls too low over the greater part of southern Texas, and in California the rainfall comes in the winter season when the plants are dormant. In the latter situation, however, the effect of the dry summer season can be overcome in many sections by thorough cultivation, rendering it possible to grow good crops without irrigation. In the drier portions of the Southwest, from about Tucson to the southern Sierras, the crop must be irrigated. Throughout California, in the higher regions where the temperature goes below 20° F., the location must be looked upon as dangerous for the culture of these plants. It must be remembered that colder temperatures can be endured by most plants in many situations in California than in southern Texas. This is due to the lack of dormancy in the plants in the latter situation, as well as a sudden and marked rise in temperature after a hard freeze.

Ideal conditions for spineless as well as spiny prickly pears are found on the high lands of Mexico where there are two rainy seasons, one in winter and the other, more pronounced, in summer. Over much of the region a minimum temperature of 25° F. is seldom experienced.

PROPAGATION.

It is seldom that the farmer who grows these plants will resort to anything but vegetative propagation. He will grow all of his plants from cuttings. A cutting will usually consist of a single joint, although larger ones can be used profitably if time, convenience, and economy of stock are no object. Mature plants can be grown much more quickly from cuttings consisting of three or four joints, but if one is establishing a plantation of any magnitude such cuttings are impracticable for several reasons. Often large plants, weighing 200 pounds or more, need only to be cut off and put into the ground. Under favorable conditions they will develop root systems and scarcely reveal the influence of the shock, provided they are not bruised in handling.

The plants can also be readily grown from seeds. This applies especially to the large, economic, rapid-growing spineless species. While experience with seed propagation is rather limited in this country, it can be stated as a general principle that the plants come true from seed and that there is little, if any, greater variation in seedlings than in vegetatively grown plants. Propagation from seeds, however, is slow and not to be seriously considered except in special cases where cuttings are difficult to obtain on account of long delays in transportation or when they must be transported for a great distance. In securing good mature plants from seed and from one-joint cuttings the time consumed will be approximately as 5 to 3.

FIG. 3.—Propagating plats of prickly pears at the Plant-Introduction Garden, Chico, Cal., immediately after the crop was harvested for distribution in April, 1911.

Seeds should be planted in a seed bed with a light soil, and their treatment does not differ materially from that of other common plants grown in the same way. The beds should be well drained and kept uniformly and moderately moist. When the young plants are 2 inches high they can profitably be transferred to the nursery row or to pots, where they can remain until they are 1 or even 2 years of age. When transplanted to the field the seedlings may be planted entire and set deep or be cut up into two cuttings each. On account of the tendency in the seedling to be rather slender it will often be better to divide the young plant into cuttings in order to gain greater stability at maturity. In practice, single-joint cuttings 1 to 3 years old will be used. The stock planted should be well matured, 1 year old or more. Younger growths will develop very well if conditions are favorable and in time make as good plants as the older cuttings, but they are not as certain and do not start off as vigorously as the latter. In propagating from a small amount of stock there will be no advantage in making cuttings more often than once each season, and then at the beginning of the growing period. There is almost no limit to the age of wood that will grow. Trunks which have largely lost their joint characters and become 8 to 10 years old will grow when cut up into suitable lengths and planted.

In the preparation of cuttings the stem should be divided as close to the articulation between the joints as possible, and the cut should be made below rather than above the articulation (fig. 3). This is not a particular matter, but the closer the incision is made to the constriction between the joints the less surface there will be to heal over.

PLANTING.

No plants are more easily handled than thornless prickly pears. They are usually grown from cuttings, which start readily. They must be in firm contact with the soil, but if the soil is moist the cuttings will usually grow, even though they are not inserted into the ground, provided, of course, the weather is not too hot, in which case scalding of the joints occurs, resulting in their destruction.

When one has but a few cuttings it is better to set them by hand, as any other tree. When a large planting is to be made, however, it is better to open up a deep furrow and distribute the cuttings at proper distances on the furrow slice. Another furrow turned in the same direction will accomplish the covering. Susequent cultivation will level off the ground sufficiently. Cuttings should not be completely covered, for these plants do not have the power of pushing up through the soil. The best plan is to have them covered one-half to two-thirds of their length. When set at an angle in this way it is thought that they make even better plants than when set upright. One of the difficulties experienced with this crop is due to the brittle nature of the stems and the lack of strength in the root system. A plant weighing 150 to 200 pounds will topple over in wet soil unless well anchored. A cutting set at an angle, as described, becomes much more stable than a cutting set upright. Besides, the cuttings are much more easily set that way. Experience indicates that cuttings should not be set deeply in the ground.

There is much yet to be determined regarding the proper distances to plant. The first plantings made by the Department of Agriculture were 3 feet apart in 6-foot rows, and this distance has been maintained at the Plant-Introduction Garden at Chico, Cal. (fig. 4). This is a fairly convenient and satisfactory plan for that locality. In situations where the plants grow more vigorously, and consequently require more room, 8-foot rows would be more advantageous.

Contrary to general belief, the cuttings need no treatment preparatory to planting. Ordinarily a cutting will consist of a single joint severed at the constriction as closely as possible. This can be done with a sharp spade or ordinary hoe straightened out so that the blade is in line with the handle. A whole plant can be chopped up in this way and the cuttings distributed in the furrow, as already described, and covered immediately, if the weather conditions are suitable. The plants should never be handled in cold, wet weather and should never be planted in poorly drained soil. They can be handled with safety, with no drying or any other preparation of the cutting, at any season from the time they begin to grow in the spring until it gets too cold in the fall. It it sometimes difficult to secure a good rooting of cuttings during the hot weather in the middle of the summer.

FIG. 4.—A view of the plats of prickly pears shown in figure 3, before harvesting.

As with any other crop, it is of the utmost importance to secure a perfect stand and as perfect plants as possible. In all plantations missing plants should be replaced by new cuttings and injured or fallen plants reset every spring at least, and oftener if possible. When an area has been once established it is an easy matter to keep up the stand, for all that is necessary is to insert a cutting from some adjoining plant at any time during the warmer half of the year.

CULTIVATION.

The cultivation of prickly pears does not differ materially from that of any other intertilled crop. In brief, it may be said that the ground should be thoroughly prepared and that the subsequent cultivation should be thorough enough and frequent enough to maintain a good tilth and keep down weeds.

At Chico, Cal., where the greater part of the stock of the Department of Agriculture has been grown, there is usually no rain from April to October. It has been the practice to clear out all weeds and put the ground in thorough cultivation immediately after the plants have been cut back for stock to distribute for propagation. This usually consists of plowing with a small moldboard plow. The trampling in this plantation incident to getting out stock is very considerable and compels the use of the plow.

Hoeing out in the rows has also been done at this time. The cultivator is then the important tool. The plowed middles are fined with a shovel-tooth or spike-tooth cultivator. Placing the plantation in good condition in April saves much labor later on. All that is necessary the remainder of the summer is an occasional cultivation with a spike-tooth or a shovel-tooth cultivator. In other regions, such as extreme southern Texas, where rains occur at irregular intervals, the same practice should govern as with cotton or corn.

The plants are shallow rooted. The best cultivation, therefore, will not be deep. Like other plants, the prickly pears adapt themselves readily and the roots can be made to grow deeper, but after the first preparation of the ground the cultivation should be shallow. When plowing is practiced, and it undoubtedly will be found profitable, it should be done at the initial preparation in the spring.

TIME OF HARVESTING.

While the spineless prickly pears, like the spiny native ones, can be used continuously as roughage it is likely that they will be more extensively employed during the drier portions of the year, when succulent feed is scarce. It can be said that, as a general thing, in regions where they are well adapted to grow they can be harvested at any time of the year. There are certain conditions which will modify this statement somewhat.

Cattle do not like the young joints for some time after they first form. Up to the time when they swell out and become in appearance more like mature joints they do not appear to be palatable. Considerable waste in feeding young joints occurs, and economy would suggest that it might be well not to harvest and feed until later in the season.

In regions where the winters are cold and wet, as in the Sacramento Valley for instance, it has been very well demonstrated that it is not safe to handle the plants during this period. Cutting the plants at this time almost invariably causes the greater part of the stems to rot instead of to heal over, as during the warmer season. At Chico no injury has resulted where harvesting has been done after the first of April. A great deal of rotting has resulted, however, when the harvesting has been done in November, indicating that the latter date is not safe. The extent of the rotting will depend in the largest measure on the temperature and moisture conditions immediately following such harvesting.

No experience has been had in southern Texas with spineless forms, but the probability is, judging from the behavior of native plantings of spiny forms, that a week of cold, wet weather following the harvesting will induce some rotting in the stems. It will, however, never be serious, as in the Sacramento Valley.

Attention is called to this matter here and in this definite way as a warning against the unnecessary cutting of these plants during unfavorable weather in the winter. This does not mean that they can not be fed at this time, for it is easy to cut enough of this stock to last nearly a month in winter without any material deterioration. In climates like that of the Sacramento Valley, however, it may not be safe to handle the plants between December and the middle of March.

STABILITY OF THE SPINELESS CHARACTER.

Much anxiety has been expressed by persons receiving plants from the Department of Agriculture as well as from nurserymen as to the stability of their spineless character. The impression appears to be rather widely held that the spineless forms under certain conditions of neglect and general lack of attention will revert to the native spiny form. Nothing could be farther from the truth, for the spineless prickly pears are distinct species or at least reasonably stable varieties which can be propagated indefinitely, especially from cuttings. They will no more revert to some other type when neglected than will corn or wheat, but, like them, will in a short time disappear entirely.

It is well to bear in mind that there are no "spineless" prickly pears that are absolutely spineless. They all have a greater or smaller number of the small spicules and nearly all of them some few spines as well.

It should also be borne in mind that the new growth on cuttings received from the Department of Agriculture or from nurseries is more likely to be spiny than the cuttings when planted. This is due not to any attempt at deception, but to the fact that in packing and transporting some of the spines and spicules get knocked off unintentionally. Frequently young growth has a few spines which drop off later. Plants sold by nurserymen are only comparatively spineless, for there are none perfectly so. These may, and usually do, under cultivation produce a few spines of no particular consequence. They will no more become too spiny for cattle to eat than will the potato develop the poisonous principles so common to its family.

While the foregoing positive statements are made, it is recognized that there may be great variations due both to reversion and habitat. It is not uncommon to find spineless and spiny joints on the same plant, and environment sometimes has a very decided influence, especially upon the development of the spicules.

Experience with this class of plants under field conditions in this country is too limited to warrant any very great generalization. It may be said that certain unfavorable conditions produce an excess of spines, and more especially of spicules. Drought, excessive heat, and the dwarfing influence of the immediate coast appear to be factors which cause an increase in the armature of these plants. In other words, dwarfing for any cause will often increase the spicules, making them much longer and—apparently, at least—more numerous and consequently more conspicuous. On the other hand, plants which grow normally and rapidly under conditions of care and attention have spicules much less noticeable and less difficult to handle. It is improbable that any of the spineless forms if completely neglected would succeed under conditions prevailing in this country. Attention is called here to the fact that some of the spiny native forms when brought into cultivation under conditions favorable to rapid growth become more spiny than in their native state.

TRANSPORTATION OF PRICKLY PEARS.

Few plants are more easily handled than prickly pears. Ordinarily no special precautions are necessary in shipping cuttings even for long distances in this country. Stock when distributed by mail is usually wrapped in newspaper and then in wrapping paper, and securely tied and labeled. Occasionally cuttings become bruised when handled in this way, but the loss has been small.

On account of the bulky character of the material the greater part of it has been distributed by freight. In such cases the cuttings in good condition are packed as tightly as possible in wooden boxes. Seldom has any paper been used. The loss is usually very small, except when long delays occur in warm weather.

When cuttings are to be shipped for great distances and are likely to be in transit for 6 to 10 weeks, as some of ours have been, it is customary to give them special treatment. In such cases it has been found necessary to root the stock before shipping it. In warm weather the cuttings will root well in 4 to 6 weeks. They can then be lifted, cleaned, and the roots and young growth trimmed off. In this condition, when properly packed to prevent bruising, it is not at all impossible to transport them in good condition for 6 to 10 weeks. It has been found that a good packing for long transportation consists in wrapping each cutting separately in newspaper, then tying it in corrugated paper. This package is then wrapped and tied in wrapping paper. Cuttings in such packages crowded tightly into wooden boxes have been carried in good condition from the United States to India.

Old cuttings are much firmer than are those of one year's growth. They are harder and much less likely to be bruised. However, they grow just as readily. For long-distance shipments, therefore, old joints are preferred. Probably those 2 to 4 years old would be most suitable.

HOW TO OBTAIN THORNLESS PRICKLY PEARS.

On account of the bulky and heavy nature of the material it is impracticable to transport prickly pears in large quantities. Where the cuttings are placed 3 feet apart in 6-foot rows, it will take nearly 2 tons of stock to plant an acre. The exact quantity will vary with the nature of the cuttings and will have an immediate relation to the conditions under which they are grown. If they are large and old the stock will be all the more valuable, but it will take a greater weight of them. The expense, risk, and difficulty of transporting such quantities are considerable. For this reason it will be best for the grower to obtain a moderate quantity to start with and establish a nursery for growing his own stock.

Under fairly good conditions one cutting will yield an average of 8 to 12 in a season. At this rate 100 will be sufficient to stock a quarter of an acre the second year.

The Department of Agriculture has collected and imported some 25 or more varieties and has distributed 8 or 10 of them in large quantities. All applicants located in situations where it is possible to grow them have received stock.

At the present time about 50 nurserymen located in regions where the prickly pear will flourish have received a stock of these plants. They are propagating these, and in many cases other material received from different sources, for sale. These nurserymen, together with two thousand or more farmers and others who were supplied with cuttings, and occasional small quantities that may be had from public parks where desirable forms have been grown for years, constitute the present sources of supply. Having introduced the stock and distributed it so widely that it can be considered well established, the Department of Agriculture, after the spring of 1912, will make no distributions except of such new accessions as may come to hand and such other forms as may not be in the trade, but will devote its energies to other phases of the investigations.

FRUIT AND FORAGE VARIETIES OF PRICKLY PEARS.

In much of the recent popular literature on the spineless prickly pear a sharp distinction is drawn between the varieties which bear edible fruit and those which are suitable for forage. There is, in the opinion of the writer, no justification for such a distinction at the present time. The phraseology is misleading and likely to induce the investor to purchase two things instead of one.

There are forms, of course, which produce more desirable fruit than others, but all the forms of spineless pears which are large and rapid enough in growth to be considered for forage produce edible fruits of good quality. One species of the botanical genus *Nopalea*, the cochineal pear, might be regarded as an exception. Its fruits are of no value. Neither is it to be considered seriously for forage in any portion of the mainland of the United States, although it is rather rapid of growth. The time may come when strains of prickly pears may be brought to superior fruitage, but this has not yet been accomplished and is not likely to be for many years, if, indeed, the fruit and forage qualities are likely to be dissociated at all. It is not clear how this can be done, except by development of strains which are more prolific than others, and even then these strains will be just as good for forage, unless the tonnage production is materially reduced. At present those forms are the most desirable for forage which produce the greatest tonnage of plant body. The same varieties produce the larger quantity of the most valuable fruit.

BOTANICAL STATUS OF THORNLESS PRICKLY PEARS.

During the last 150 years names have been given to a number of species of nearly spineless prickly pears. Among them are those known to the botanist as *Opuntia ficus-indica*, *Opuntia crassa*, forms of *Opuntia robusta*, *Opuntia decumana*, *Opuntia elongata*, *Opuntia fusicaulis*, and others. Information regarding the whole genus, however, and more especially the spineless group, is in such confusion that the species can not be satisfactorily segregated until a great deal more careful study has been devoted to it. The last monograph issued admitted but two species to the group, but there are several more described as being spineless. The facts are that the spineless prickly pears scarcely constitute a separate group. When genetic relationships are considered, the majority of them should doubtless be distributed among the spiny species, to which they are most closely related and from which they possibly originated.

Issued March 9, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 484.

SOME COMMON MAMMALS OF WESTERN MONTANA IN RELATION TO AGRICULTURE AND SPOTTED FEVER.

BY

CLARENCE BIRDSEYE,
Assistant, Bureau of Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., January 4, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a farmers' bulletin a report on Some Common Mammals of Western Montana in Relation to Agriculture and Spotted Fever, by Clarence Birdseye, assistant in the Biological Survey. The investigations on which this report is based were carried on in western Montana for several years, especially in the Bitterroot Valley, in cooperation with the Bureau of Entomology and the Montana State Agricultural Experiment Station. As Rocky Mountain spotted fever is transmitted to man by wood ticks and as the earlier stages of these insects are passed almost wholly on native wild mammals, some of which are exceedingly destructive to crops, the facts here presented have an important bearing on human health as well as on agriculture.

Respectfully,
Henry W. Henshaw,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

CONTENTS.

Page.

- Introduction 5
- Poisoning rodents 7
  - Some common rodent poisons 7
  - Methods of using strychnine 8
  - Necessity of spring poisoning 8
  - Cooperation 9
- Columbian ground squirrels 10
  - Distribution 10
  - As tick hosts 10
  - Hibernation and breeding 11
  - Food habits 11
  - Injury to crops 12
  - Poisoning 14
    - Formula I. Poisoned groats 14
    - Formula II. Poisoned biscuits 15
    - Putting out the poison 15
  - Trapping 16
    - Methods of setting traps 16
  - Fumigation 19
  - Conclusions 20
- Chipmunks 20
  - Distribution 20
  - As tick hosts 20
  - Injury to crops 22
  - Poisoning 22
    - Formula III. Flour-coated wheat 23
    - Formula IV. Waterproof wheat poison 23
  - Other methods of destroying chipmunks 23
  - Conclusions 24
- Side-striped ground squirrels 24
  - As tick hosts 24
  - Injury to crops 25
  - Habits 25
  - Poisoning 25
- Pine squirrels 26
  - Injury to crops 26
  - As tick hosts 27
  - Destruction 27
- Woodchucks 27
  - Distribution 27
  - Hibernation, breeding, and food 28
  - Injury to crops 28
  - As tick hosts 28
  - Poisoning 28
  - Trapping 29
- White-footed mice 29
  - Distribution and habits 29
  - Poisoning 30
- House mice 30
- Wood rats 31
  - As tick hosts 31
  - Destroying 31
- Meadow mice 32
  - Distribution and habits 32
  - Injury to crops 32
  - Poisoning 34
    - Formula V. Green alfalfa 34
    - Formula VI. Alfalfa hay 36

Page.
Pocket gophers 36
  Distribution and habits 36
  Injury to crops 37
  As tick hosts 38
  Poisoning 39
    Formula VII. Poisoned vegetables 39
  Trapping 40
Rabbits 40
  Distribution and habits 40
  As tick hosts 41
  Injury to crops and fruit trees 41
  Rabbit-proof fences 42
  Trunk washes 42
  Trunk wrapping 43
  Poisoning 43
  As food 43
Badgers 44
Weasels 45
Big game animals 45
  Mountain goats 45
  Elk 45
  Deer 45
  Bears 46
  Coyotes 46
Summary 46

ILLUSTRATIONS.

Page.
FIG. 1. Twenty-seven rodents killed with 7 cents worth of poisoned grain 9
2. Columbian ground squirrel 10
3. Columbian ground squirrel burrow in wheat field 12
4. Carrots ruined by Columbian ground squirrels 13
5. Washout caused by burrow of Columbian ground squirrel 13
6. "Hole set," made with ordinary outside-spring steel trap 17
7. Four-foot cedar trap stakes at burrows of Columbian ground squirrels 17
8. "Surface set," made with "jump" steel trap 18
9. Two Columbian ground squirrels caught in a "surface-set" jump trap 18
10. A convenient method of carrying 200 traps and stakes 19
11. Outfit for use in bisulphiding ground squirrel burrows 20
12. Yellow-bellied chipmunk 21
13. Chipmunk damage in wheat field 21
14. Seed-spot of pine seeds pillaged by chipmunks 22
15. Side-striped ground squirrel killed by carrying poisoned grain in cheek pouches 24
16. Dissection showing 357 kernels of whole oats in cheek pouches of side-striped ground squirrel 25
17. Young pine squirrel 26
18. Woodchuck, which injures crops and spreads spotted fever 27
19. Partly engorged adult wood ticks on woodchuck 28
20. Mouse refuge in holes left by burned stump and roots 29
21. White-footed mouse killed by carrying 17 kernels of poisoned wheat 30
22. Young wood rat 31
23. Meadow mouse caught in unbaited trap 32
24. Diagram of meadow mouse runway 33
25. Mouse-infested stump in hayfield 33
26. Alfalfa field ruined by meadow mice 34
27. Apple tree killed by meadow mice 35
28. Pocket gopher with pouches full 36
29. Pocket gopher with pouches turned inside out 37
30. Double line of gopher hills 37
31. Stock of apple tree killed by pocket gophers 38
32. Pocket gopher mound in wheat field 39
33. Apple tree injured by rabbits 41
34. Weasel, an active enemy of harmful rodents 44

SOME COMMON MAMMALS OF WESTERN MONTANA IN RELATION TO AGRICULTURE AND SPOTTED FEVER.

INTRODUCTION.

There are few localities in the West where the commoner species of native mammals, especially rodents, are so important as in certain parts of western Montana; for there they must be considered in relation not only to agriculture but also to the Rocky Mountain spotted fever. Especially serious is the damage done to crops and young orchards by ground squirrels, pocket gophers, and rabbits; while in areas intended to be reforested the destruction of the tree seed by chipmunks and white-footed mice renders the extermination of these rodents necessary.

The Rocky Mountain spotted fever is a germ disease which is communicated from wild animals to human beings by the bite of the spotted-fever tick (*Dermacentor venustus*). In a number of experiments carried on by Dr. H. T. Ricketts [1] and others, spotted fever has been repeatedly communicated to healthy guinea pigs by the bites of wood ticks which had previously fed on animals sick with the fever. Not only has the fever been thus carried from one guinea pig to another, but it has been communicated directly to these animals by ticks picked up in regions where cases of the fever are known to have been contracted by men. Moreover, the germ which causes spotted fever is transmitted from infected female ticks to their offspring, and in a number of experiments the disease has actually been communicated simply by the injection into a healthy guinea pig of a few crushed eggs of an infected tick. Such experiments as these—and numbers have been made, all with similar results—are enough to prove that ticks can and do transmit spotted fever. Only a small percentage of ticks, however, even in the worst "fever country," are infected, and thus people may be bitten by ticks many times without bad results. Moreover, infected ticks may bite people and communicate the disease and then become detached without being noticed, there thus being in such cases no assignable cause for the infection.

One of the current local theories is that spotted fever is caused by drinking impure or very cold water—in other words, that the fever is contracted through the digestive system. Of course the drinking of bad water may, and undoubtedly often does, cause sickness. But that neither water nor anything else when taken into the stomach can possibly cause spotted fever is proved by the fact that even infected blood has been fed to guinea pigs, which are very susceptible to this disease, without bad results. In short, spotted fever, like malaria, is believed to be contracted only by blood infection, and not, like typhoid, through the digestive system.

---

[1] Fourth Biennial Report (for 1907 and 1908) of State Board of Health of Montana, pp. 106–111 and 161–183.

In the brief life history of the tick there are four distinct stages—egg, " seed " or larva, nymph, and adult. Although the adult ticks have been found on mountain goats, coyotes, badgers, woodchucks, snow-shoe rabbits, and on the only bear examined, by far the greater number, at least 95 per cent, feed on domestic stock. When full of blood the females drop from their hosts to the ground, become inactive, and after a time lay as many as 4,000 eggs. They then die. After several weeks these eggs hatch, the young ticks, called seeds, being about the size of mites. These seeds then crawl up blades of grass or other low vegetation and, if opportunity offers, become attached to some passing small animal. After feeding on this animal for from three to eight days they become full of blood, drop off, and seek shelter. Then, after remaining inactive for a few days, they molt and emerge as nymphs, which somewhat resemble wood ticks, but are very much smaller. These nymphs, like the seeds, attach to some small animal—never, so far as known, to men—feed for a few days, drop off, become inactive, molt, and after about two weeks emerge as the third and last stage, the familiar wood tick. Thus the life cycle is completed in from one to three years.[1] Any tick failing to find a host in any one of the three stages dies of starvation.

Since it is known that spotted fever is communicated from wild animals to human beings by the bite of infected wood ticks and that the two younger stages live almost entirely on small native rodents—from which they occasionally contract the infection—it is evident that these tick hosts should be destroyed, at least around ranches. The extensive damage done by the same animals to agricultural interests is another important reason for their destruction.

The chief purpose of this publication is to point out the best methods of destroying these native mammals. The investigations on which it is mainly based have been carried on for several years in the Bitterroot Valley, Mont., by the Biological Survey in coöperation with the Bureau of Entomology and the Montana Agricultural Experiment Station. During the seasons of 1910 and 1911 the author, representing the Biological Survey, worked in cooperation with Mr. W. V. King, of the Bureau of Entomology, to whom he is indebted for many of the data concerning the host relations of the ticks, as well as for many observations on the distribution and habits of the mammals treated herein.

---

[1] For detailed information in regard to the life history of the tick see Bull. 105, Bureau of Entomology.

POISONING RODENTS.

Poisoning is in many cases the most effective and least expensive means of destroying harmful rodents; but methods of poisoning to be successful must be carefully worked out with reference to particular kinds of animals and localities. The formulas given in this bulletin should be closely followed, as the amounts of poison recommended have been carefully determined.

SOME COMMON RODENT POISONS.

Strychnine, arsenic, and phosphorus are the three most generally used rodent poisons. The following is a brief summary of the characteristics of each:

Strychnine is a vegetable poison obtained from the bean of the nux vomica tree, the chief supply coming from the Malabar coast, India. The strychnine of commerce consists of colorless crystals or white powder, and there are two forms commonly used as rodent poisons—the alkaloid and the sulphate. The alkaloid is only slightly soluble in water, and in rodent poisons is usually powdered and applied to grain in a coating of starch or flour paste. The sulphate dissolves readily in either hot or cold water and is used in solution. Both are deadly and act very quickly, causing tetanus, convulsions, and a speedy and comparatively merciful death. The bitterness of strychnine is the chief drawback to its use, because ground squirrels, chipmunks, and some other rodents refuse to eat bitter baits when their natural food is plentiful. The addition of saccharine to strychnine baits has formerly been recommended, but recent experiments have shown that it does not conceal the bitterness of the poison, and is therefore of little value. Although an expensive poison, strychnine is so powerful that it is on the whole more economical than arsenic or phosphorus, and its use is strongly recommended by the department.

Yellow phosphorus is extensively used as a poison for ground squirrels, rats, prairie dogs, and other rodents. But although it is both cheap and effective, the great personal danger accompanying its use and the fact that it causes a painful, lingering death are such serious objections that the Department of Agriculture strongly advises against its use.

White arsenic is an almost tasteless, insoluble, rather weak, and very cheap poison, used extensively in rat baits. Its action on rodents is variable and uncertain. It often causes vomiting, and small doses tend to cause immunity. Although it is almost tasteless, ground squirrels and chipmunks refuse to eat it except when their natural food is very scarce, and then strychnine also would be eaten and would be much more effective. During the spring and summer of 1911 the author tried arsenic thoroughly and was forced to the conclusion that it is not a satisfactory poison for any of the rodents mentioned herein, except woodchucks and possibly wood rats.

Potassium cyanide is an exceedingly deadly and dangerous poison, which has been much used to destroy ground squirrels and prairie dogs. Although cheap, it absorbs moisture and quickly decomposes when exposed to the air, and is therefore unsatisfactory. It is not recommended.

Corrosive sublimate, barium carbonate, squill, and nux vomica each have such serious faults that they are not at present recommended.

METHODS OF USING STRYCHNINE.

Three methods of applying strychnine to baits are recommended in this bulletin. In one the food is soaked in a solution of sulphate of strychnine, in another it is coated with starch or flour paste containing powdered alkaloid of strychnine, and in the third it is mixed with starch containing the alkaloid and is then compressed into squares or "biscuits."

Grain soaked in sulphate solution is very bitter and is not recommended except when the bait is to be soaked in tallow to render it waterproof. A sulphate solution is valuable in preparing baits for rabbits and meadow mice.

Starch or flour paste containing powdered alkaloid is recommended, because baits coated with these materials can be prepared much more easily than those soaked in sulphate solution, because animals carrying coated baits are often killed simply by the absorption of part of the poison directly into the blood through the mucous membranes of the mouth or cheek pouches, and because the centers of kernels of coated grain remain sweet and are more freely eaten than those made bitter all through by soaking in sulphate solution.

It is sometimes necessary to take special precautions to avoid killing birds, and in such cases "oatmeal biscuits" are recommended.

NECESSITY OF SPRING POISONING.

Ground squirrels, chipmunks, and mice usually refuse to take poisoned baits when natural food is abundant, and preparations which are effective at one time of the year are often of no use at another. The best time to use poison is in early spring, and the work should be done then if possible. Columbian ground squirrels can not be successfully poisoned at any other season. Thus, although 27 dead ground squirrels, chipmunks, and mice (fig. 1) were found from 1½ pints (7 cents' worth) of poisoned grain placed early in the season, no dead animals were found from 5 bushels of the same preparations put out after seeds and berries became abundant.

COOPERATION IN RODENT POISONING.

One of the most serious difficulties encountered in a campaign against rodents or other pests lies in the refusal of a certain proportion of the people in most communities to take part in such work. The lands of these individuals then serve as breeding grounds from which the surrounding areas are constantly restocked. For this reason at the outset of such a campaign every effort should be made to secure the cooperation of the entire community. It will greatly aid in a campaign against rodents to have the poison bought in quantity and the poisoned preparations made in large amounts at a central point, whence the people taking part may secure it at cost. If each individual made his own poisoned material, it would be a complicated and unduly expensive process for small ranchers. The convenience of being able to get the prepared poison in small quantities would greatly encourage small proprietors to take an active part in the work. This is proved by the fact that every year thousands of dollars are spent for inferior and disproportionately expensive proprietary poisons simply because they can be easily obtained. One Montana orchard company last year bought 189 pounds of a certain

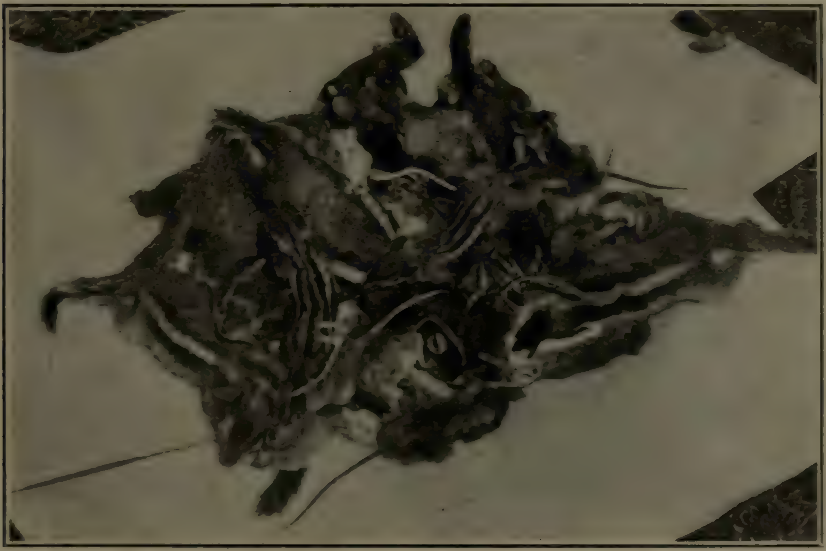


FIG. 1.—Twenty-seven ground squirrels, chipmunks, and mice killed by 7 cents worth of poisoned grain.

proprietary squirrel poison at a net cost of 23 cents a pound. In this bulletin a much more effective preparation costing not more than 12 or 15 cents a pound is recommended. Another advantage of cooperation is in the purchase of material at wholesale prices. Thus, while drug stores retail strychnine at from $1.50 to $2 an ounce, it may be bought in quantities of 5 ounces or more at from 60 to 65 cents an ounce.

It is recommended therefore that, whenever possible, standard poisons be mixed in quantity by State experiment stations, counties, commercial clubs, granges, or other associations and then distributed at cost price to the large number of individuals who would thus be induced to use them. In the Bitterroot Valley a part of the spotted-fever fund appropriated by the State might well be used for this purpose.

FIG. 2.—Columbian ground squirrel.

COLUMBIAN GROUND SQUIRRELS.

DISTRIBUTION.

The Columbian ground squirrel (fig. 2), known also as picket pin and gopher, is by far the most important rodent in western Montana in its relations both to agriculture and to spotted fever. It occurs also in northern Idaho, northeastern Oregon, eastern Washington, and the mountains of southwestern Alberta and southeastern British Columbia.

AS TICK HOSTS.

The Columbian ground squirrel is undoubtedly the most important host of the two younger stages of the fever tick, and is almost always infested with ticks when occurring in suitable country. From the 341 specimens examined by Mr. W. V. King and myself in the course of these investigations 841 seed and 1,234 nymphal wood ticks were taken, an average of 6.09 for each animal. It can readily be seen, therefore, that in fever-infested localities the destruction of this most important host of young wood ticks must be an important supplementary part of any campaign for the control of the disease.

HIBERNATION AND BREEDING.

Although the habits of this ground squirrel vary considerably with climate and locality, in the warmer valleys it usually emerges from hibernation during the latter part of March. It begins rutting about a week or 10 days later and, as the gestation period is about 28 days, the young (averaging about 4 to 5 in a litter) are born in early May. At first they are blind, naked, and helpless. In about three weeks, however, they come to the surface of the ground for the first time and at once begin to eat various sorts of green food. Of 21 young squirrels weighed between June 6 and 12, 1911, about a week after their first appearance, the lightest tipped the scales at 2.75 ounces and the heaviest at 8 ounces. Eleven killed on June 10 averaged 3.75 ounces. The lightest of 30 adults weighed between May 30 and August 15 was 11 ounces and the heaviest 26 ounces, the average being 17.5 ounces.

By about June 1 the old males have begun to recover from the strain of the rutting season and by the middle of July most of them are very fat. From then until they enter hibernation they remain close to their burrows and do little but sun themselves and eat. The old females do not begin to put on fat until about the middle of July and do not become so fat as the males until just before hibernating, if at all.

In most parts of western Montana the Columbian ground squirrels enter hibernation about the middle of August. In the colder parts, however, where they do not emerge from hibernation until the latter part of April, they remain active a full month longer; and at Almota, Wash., they "hole up" in July, having put in an appearance early in February. Thus it appears that the time they enter hibernation is usually about four and a half or five months after they emerge in the spring.

FOOD HABITS.

The Columbian squirrel, more than most other ground squirrels, prefers tender green vegetation to ripe seeds and grains. Probably as a result of these food habits its cheek pouches are small and little used. Among the green foods most attractive to these squirrels are dandelion heads, clover, alfalfa, timothy, lettuce, strawberries and various other berries, young carrots, bean and pea vines, and growing grain. Oats (whole, hulled, or rolled) are preferred to any other grain; and wheat, though not so well liked, is readily eaten. Barley and rye are seldom taken.

INJURY TO CROPS.

Although ground squirrels are not so serious a pest in Montana as in some other States, the damage they do in many localities is sufficient to warrant their destruction.

Growing grain is eaten by ground squirrels from the time it first appears above ground until the animals enter hibernation. (Fig. 3.) I have seen many wheat and oat fields which were seriously damaged by ground squirrels; and it is safe to say that every one of these animals in a grainfield annually causes at least a dollar's loss. This great damage is well illustrated by the experience of a rancher near Pullman, Wash. In the spring of 1910 he bought 1,000 traps and started to clear the squirrels off his whole ranch. Included in the land on which the animals were exterminated was an 80-acre piece from which the owner had for six years been unable to secure a crop, but after the squirrels were killed off this piece yielded an average of 35 bushels of wheat to the acre.

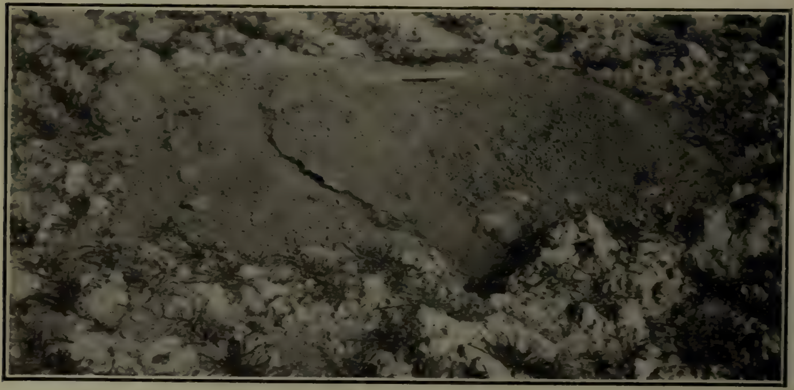


FIG. 3.—Columbian ground squirrel burrow in wheat field.

Carrots, potatoes, beans, peas, and other garden truck are often seriously damaged. Figure 4 shows squirrel work in a carrot field near Florence, Mont. The manager of one of the orchard companies southwest of the same town reported that in 1910 ground squirrels caused the company a total loss of 5 acres of beans, the plants being attacked from the time they sprouted until the pods were formed.

In hayfields squirrels cause serious loss both by eating hay and by covering considerable areas with their mounds, which are a great annoyance when the fields are mowed.

In orchards the most serious damage is usually done to the irrigation systems; but Mr. Moody, president of the Como Orchard Land

Co., of Hamilton, Mont., reports that the depredations on that company's lands assumed a very unusual and serious nature, for the squirrels attacked the buds of the trees themselves and actually

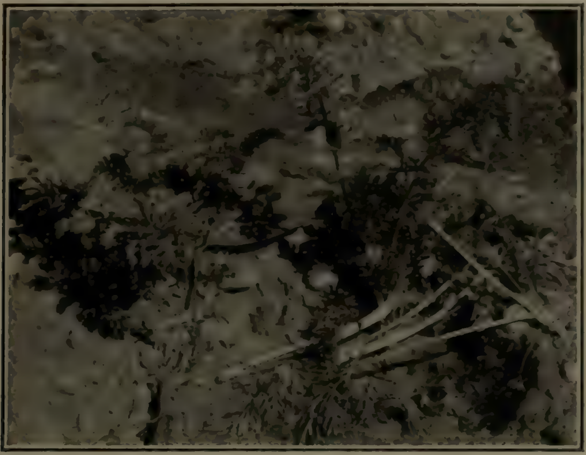


FIG. 4.—Carrots ruined by Columbian ground squirrels.

killed about 45,000 trees in one year. This company at once took systematic steps to destroy the animals on their land, and spent over $1,700 for the work in 1910 and 1911.

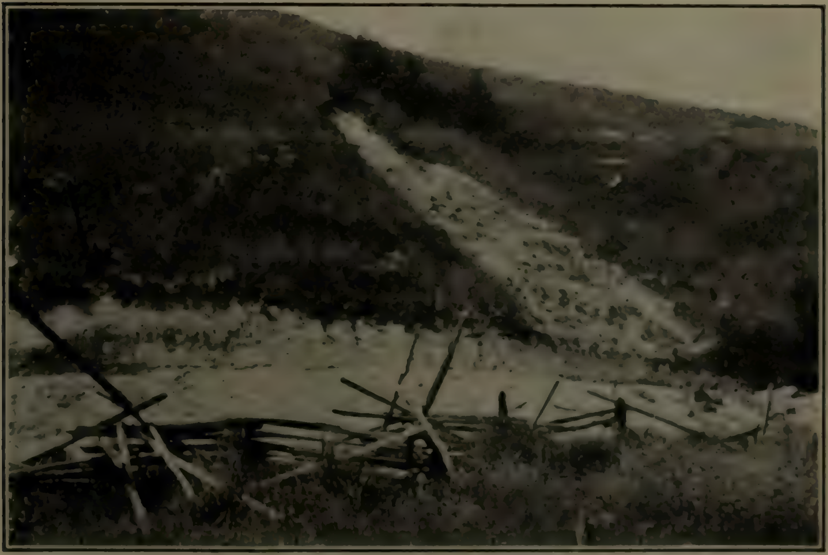


FIG. 5.—Washout caused by burrow of Columbian ground squirrel.

Ground squirrel holes are a serious menace to the safety of irrigation systems. Figure 5 shows a washout on a side hill, caused by irrigation water escaping through a squirrel burrow from an orchard on top of the bench. The chief engineer of the Bitterroot Valley Irrigation Co. writes that in 1911 $184.75 was spent to protect the company's main irrigation ditch and that each of the numerous development camps waged its own war against the squirrels.

POISONING COLUMBIAN GROUND SQUIRRELS.

The Columbian ground squirrels are probably the most difficult of the native rodents to poison. The chief reasons for this are that the animals prefer green vegetation to grain, that they do not store food, that they have an intense dislike for bitterness, and that they for some cause refuse to eat arsenic baits. For these reasons several years of experimenting have failed to produce a bait which is effective on the Columbian ground squirrels when green vegetation is abundant. But the work done during 1911 indicates that these animals can be successfully poisoned if the poison is placed early in the spring when they first come out of hibernation. This means that the baits must usually be put out not later than the 1st of April and that they will not succeed after vegetation is well started.

Hulled oats (or "groats," as they are technically known) are preferred by these squirrels to all other forms of grain and are much better than wheat for use in poisoning. Groats can be secured at oatmeal mills, usually at a cost of about 3 or 4 cents a pound. Ordinarily in the process of manufacture the groats are raised to a high temperature in coffee roasters, but the unroasted grain is better for squirrel bait, and should be secured where possible. Although hulled oats are more expensive than wheat, they should nevertheless be used, for they will give better results. Individual ranchmen making up small quantities of poison are likely to have difficulty in securing groats—another argument in favor of the wholesale manufacture and retailing of squirrel poison by associations.

Care should always be taken to avoid poisoning useful birds, and in some cases a special "bird-proof" preparation is necessary. The poison which best meets these requirements is a small square "biscuit" of poisoned material, which when dry is too hard for small birds to peck to pieces and too large for them to swallow whole. These baits require considerable time to prepare, and therefore cost more than poisoned grain; but they are effective and are the only baits which will not endanger birds. They are, moreover, more resistant to rain than loose grain.

The following preparations are recommended, but must be used early in the spring:

FORMULA I. POISONED GROATS.

Hulled oats ("groats")	4 quarts.
Strychnine alkaloid (powdered)	½ ounce
Flour	5 level tablespoonfuls.
Cold water	1 cup.

Place the flour in a bowl and add one-third cup of cold water, stirring until no lumps remain. Then stir in the other two-thirds cup of cold water and heat to boiling point over a slow fire, stirring constantly. Remove the paste from the stove, mix in the powdered strychnine alkaloid, and pour the poisoned paste over the groats, mixing until every kernel is evenly coated. Spread and dry the poison, and it may be either used at once or kept indefinitely. A galvanized iron washtub is an excellent receptacle in which to mix poisons. A heavy round-bottomed china or earthen cup and a round-headed iron bolt about 5 inches long make a good substitute for mortar and pestle with which to powder strychnine crystals.

The addition of a quarter ounce of powdered dry extract of licorice and 2 teaspoonfuls of strawberry or raspberry sirup (such as is used at soda fountains) will aid to disguise the bitterness of the strychnine and will improve the taste of the bait, but these two ingredients are not necessary.

Poisoned wheat may be prepared in the same way, except that only two-thirds as much flour paste is needed, for the glossy outer coating of the kernels does not absorb moisture as readily as do groats.

FORMULA II. POISONED BISCUITS.

Oatmeal (rolled oats)	4 quarts.
Strychnine alkaloid (powdered)	½ ounce.
Gloss starch	2½ heaping tablespoonfuls.
Water	1 quart.

Stir the starch, dissolved in one-half cup of cold water, into 1¾ pints of boiling water, thus making a smooth paste of medium thickness, and into this stir the powdered strychnine. Then mix it thoroughly with the oatmeal, forming a stiff dough. Press this dough into sheets one-fourth inch thick and cut it into one-half inch squares. After these have been dried in the sun—not in an oven—they will become hard and will keep indefinitely. This formula should make about 3,000 or 3,500 biscuits, each of which will contain enough poison to kill a squirrel. A little crushed starch or flour will prevent the dough from sticking to hands and utensils. In preparing small quantities of biscuits a flat board may be used to press the dough into sheets and a knife to cut it into squares. But where the baits are to be manufactured in bulk a rotary confectioner's or druggist's cutter will facilitate the work.

PUTTING OUT THE POISON.

A teaspoonful of loose grain, or two of the poisoned biscuits, should be placed at the entrance of each occupied squirrel hole. It will thus be more available for the squirrels and less likely to attract the attention of birds than if scattered broadcast. Poisoned baits should never be placed in ground-squirrel holes, for when so placed they are trampled into the dirt and are not eaten. When stock is ranging in the poisoned territory the grains may be scattered a little, not too much.

TRAPPING.

Next to poison, traps are the most effective means of destroying the Columbian ground squirrel. In fact, only by their use can the animals be exterminated in a given locality, for there are always some individuals which refuse to take poisoned baits or which escape fumigation. But since trapping is more expensive than poisoning, the two methods should be combined, as many as possible of the animals being killed with strychnine and the rest caught with traps. Systematic trapping has not, in most localities, been as much resorted to as it should have been. It can not be too strongly recommended as a supplement to poison.

The value of systematic trapping is well proved by the results which have attended its use in the rolling wheat lands of Whitman County, Wash., where it has steadily advanced in favor and has now largely supplanted poisoning. One or two of the ranch owners are operating 2,000 or more traps, and a number are using from 500 to 1,000.

Mr. Mert Davis, of Pullman, is more than anyone else responsible for the introduction of systematic squirrel trapping, and his experience is valuable. Two years ago he began trapping on a newly purchased ranch of 400 acres, all of which was very badly infested with squirrels. During the season of 1909 he used 1,200 traps, continuing the work through 1910 and into the spring of 1911, when only a few scattered squirrels remained; and these were secured soon afterwards. This ranch is now entirely free from squirrels, and, although the surrounding fields have not been trapped, is protected from invasion by keeping traps in the holes around the boundaries. Mr. Davis believes that old rusty traps are at least as good as shiny new ones. The squirrels caught were chopped up and fed to the chickens.

METHODS OF SETTING TRAPS.

There are two methods of setting squirrel traps, the "hole set" and the "surface set."

The hole sets are the ones almost universally employed at present. In this method jump traps, or ordinary steel traps (No. 1 are better than No. 0), are set in every hole. (Fig. 6.) If these traps are tended every day, all the squirrels are sure to be caught. The principal objection to this method is the very large number of traps required, for since there are often ten or fifteen times as many holes as there are squirrels a large number of traps often cover surprisingly little ground. Mr. Claude Haines, a Whitman County rancher, bought and operated 1,000 traps in 1911. He used 4-foot trap stakes split from waste fence posts, but believes that half laths would be cheaper and fully as good. (Fig. 7.) He and another man worked one and three-quarter days staking and setting the 1,000 traps the first time, but on another occasion Mr. Haines alone set 500 traps in a day and himself tended the whole 1,000 traps. He used nothing but hole sets. One of the unfortunate features of this method of setting traps is that weasels or other squirrel enemies are sure to be caught.

FIG. 6.—"Hole set," made with ordinary outside-spring steel trap.

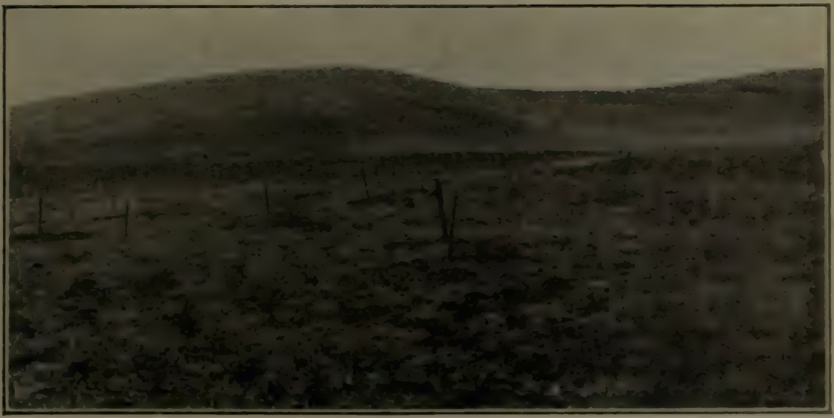


FIG. 7.—Four-foot cedar trap stakes at burrows of Columbian ground squirrels.

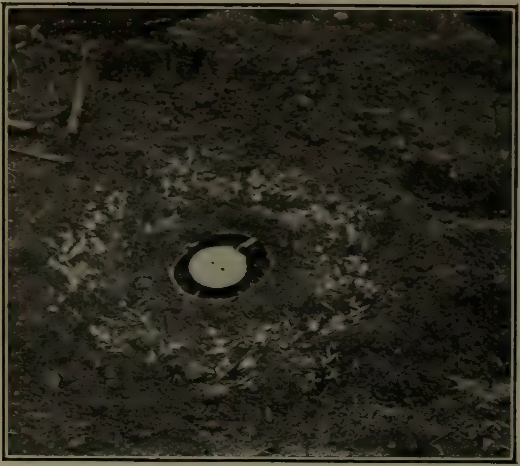


Fig. 8.—"Surface set," made with "jump" steel trap.

Surface sets are made by sinking traps flush with the surface of the ground near squirrel burrows and sprinkling oats or other bait in a circle just outside of the jaws. (Figs. 8 and 9). The advantages of this method of setting are that fewer traps are required to cover a given number of burrows and that enemies of squirrels using the burrows are not endangered. The disadvantages are that the surface sets require more time to make, that they occasionally catch meadow larks, quail, or other valuable birds, and that they are not always effective when green vegetation is abundant. "Jump" traps with their large pans are better suited to surface sets than are the small-panned outside-spring traps, for the animals are likely to walk around the latter sort of traps instead of stepping into them. Sometimes clods of earth placed on opposite sides of the traps serve to guide the squirrels into them.

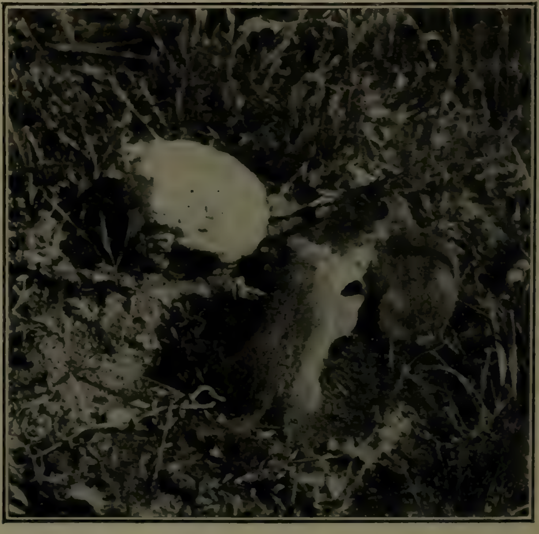


Fig. 9.—Two Columbian ground squirrels caught in a "surface-set" jump trap.

The most effective trapping can be done by using a combination of hole and surface sets made as circumstances suggest, and with jump traps, perhaps one-third of which are No. 1 and the rest No. 0. In this case the No. 1 traps should be reserved for the surface sets and the smaller size used in the holes. As a rule waste land, where burrows are numerous, can be trapped to the best advantage with surface sets, while hole sets are more effective in cultivated areas, where each squirrel has but a few holes. Traps should be visited at least once a day, in order both to secure the best results and to avoid causing imprisoned animals unnecessary suffering. Figure 10 illustrates one way of handling a considerable number of traps.

Ordinary No. 1 steel traps cost about $125 to $130 a thousand and "jump" traps are slightly more expensive.

FUMIGATION.

Fumigation with carbon bisulphid is very effective when employed early in the season while the ground is still damp. Dry ground rapidly absorbs the fumes. Crude carbon bisulphid suitable for this purpose costs from 8 to 10 cents per pound in 50-pound carboys or drums. Since it is a volatile liquid and rapidly loses strength on exposure to the air, it should be kept in tightly corked bottles or cans.

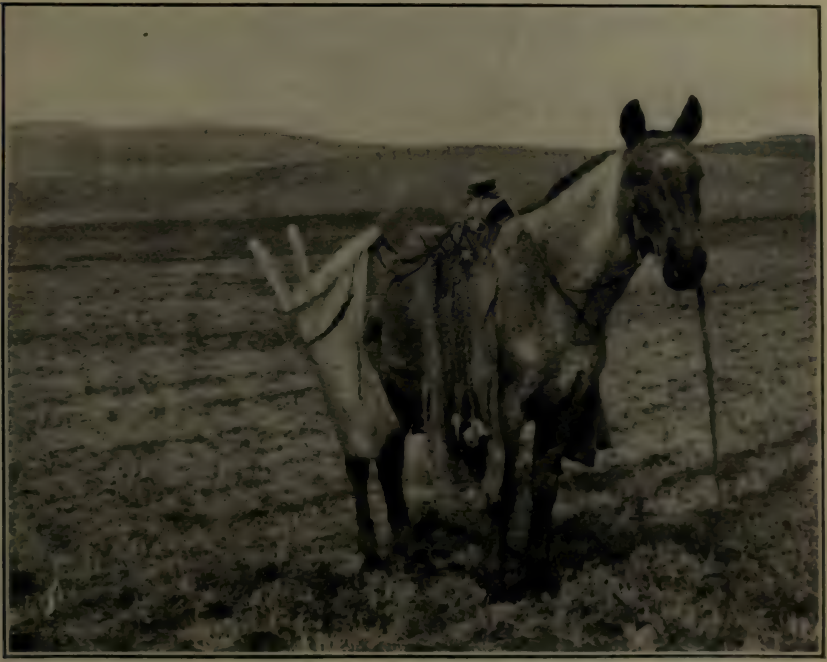


FIG. 10.—A convenient method of carrying 200 traps and stakes.

When bisulphid is used to fumigate squirrel burrows, about a tablespoonful should be poured on a piece of loosely rolled cotton or other absorptive material and pushed as far as possible down the burrow, the opening to which should then be immediately closed. Every hole should be treated, and in case of outlying burrows a little larger amount of the bisulphid should be used. As carbon bisulphid is inflammable and the fumes highly explosive, it should never be opened near a fire or where a person is smoking. Figure 11 shows an excellent outfit for using bisulphid.

CONCLUSIONS.

The Columbian ground squirrel is the worst rodent pest in western Montana, and is of especial importance in regions infested with spotted fever, where it is the principal host of the younger stages of the "fever tick," or wood tick. It is also the most difficult rodent in the Northwest to control. The methods of eradication recommended are early spring poisoning, followed at once by the systematic use of traps or carbon bisulphid.

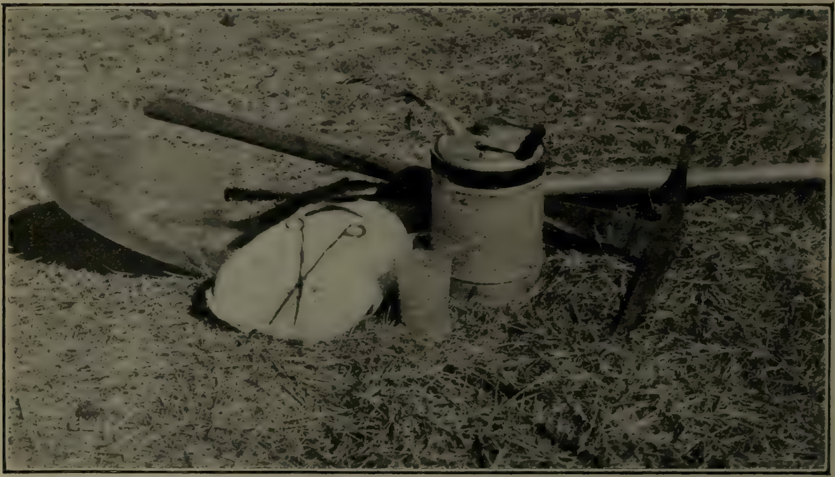


FIG. 11.—Outfit for use in bisulphiding ground-squirrel burrows.

CHIPMUNKS.

DISTRIBUTION.

Several kinds of chipmunks occur in western Montana, but they are so nearly alike in appearance and habits that for the purposes of this work no distinction is made between them. (Fig. 12.) Although chipmunks are not nearly so important as are Columbian ground squirrels, they have a very definite relation both to agriculture and to spotted fever.

AS TICK HOSTS.

Probably more young wood ticks feed on chipmunks than on any other kind of animal except Columbian ground squirrels. Of about 190 examined during 1910 and 1911, many were found to be tick infested and some carried 50 or more seeds or nymphs. Chipmunks occur commonly around unoccupied log cabins, in stone and rail fences, and in pastures where there is more or less brush and fallen timber, and in this way come into close contact with man and with domestic animals. When young ticks dropped by chipmunks around ranches molt and emerge as adult "wood ticks" they have a good chance to become attached to persons or domestic stock. It is therefore especially important that in any campaign against spotted fever an effort be made to kill off the chipmunks around ranches.

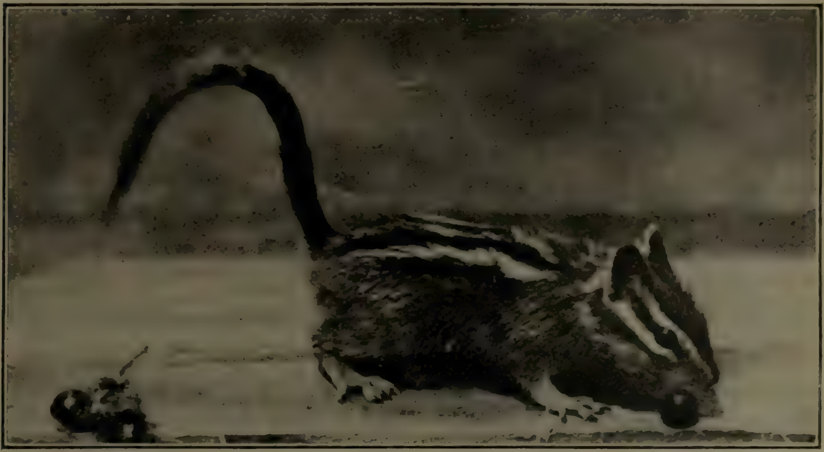


FIG. 12.—Yellow-bellied chipmunk.

FIG. 13.—Chipmunk damage in wheat field.

INJURY TO CROPS.

Although chipmunks occasionally do much damage to peas, strawberries, or other such crops, they are chiefly harmful in wheat fields, where they cut the heads from the grain, usually after the kernels are in the dough stage. Often the animals start to climb the stalk, bend it down, cut off the head, carry it to a near-by stump or fence, and there hull and eat it. (Fig. 13.) Very frequently, however, they do not content themselves with this rather slow method, but break down stalk after stalk, taking only a few kernels from each. A field in which chipmunks adopt these tactics is soon seriously damaged by the bending and matting together of the stalks. Such a field can easily be distinguished from one injured by ground squirrels, which eat off the stalks rather close to the ground. The wheat fields in narrow valleys and on benches near the timber are likely to suffer most severely from the depredations of these animals.

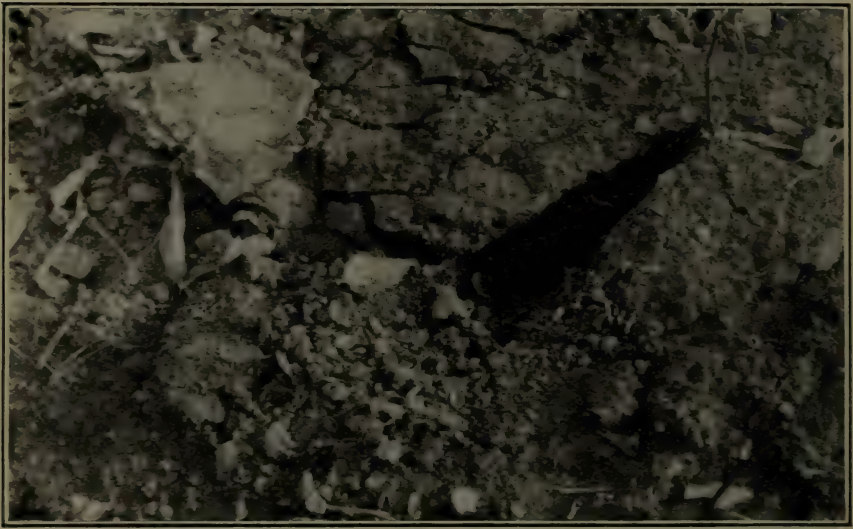


FIG. 14.—Seed spot of pine seeds pillaged by chipmunks.

Chipmunks and mice are both very fond of the seeds of pines, firs, and other forest trees, and it is absolutely essential that areas which are to be replanted be rid of these animals. Figure 14 shows a seed spot dug out by chipmunks on the Cabinet National Forest. One chipmunk has been seen to visit 38 seed spots in four minutes.

POISONING CHIPMUNKS.

Although chipmunks are not so hard to control as are Columbian ground squirrels, they have the same dislike for the intensely bitter taste of strychnine baits, and must therefore be poisoned in the spring or early summer, before the seeds and berries which form their favorite food have ripened. Since wheat is liked by chipmunks better than any other grain, it forms the best medium for the administration of poison. Dried currants are relished even better than wheat and make an excellent bait when treated with the flour coating described below. When a waterproof poison is desired, the tallowed wheat recommended in Formula IV will give good results. To be effective these poisons must be placed in the spring or early summer. If grainfields are to be protected, a strip of adjoining country must be poisoned before the grain begins to head.

FORMULA III. FLOUR-COATED WHEAT.

Wheat	20 quarts.
Strychnine alkaloid (powdered)	1 ounce.
Flour	¾ cup.
Water	1 quart.

Mix the flour with a cup of cold water to form a thick, smooth paste, and then stir in the remaining 1½ pints of cold water. Heat to boiling point over a slow fire, stirring constantly. Then remove from the stove, mix in powdered strychnine alkaloid, and mix with the wheat until every kernel is evenly coated. Spread and dry the preparation, and it may either be used at once or kept indefinitely.

Although alkaloid of strychnine is here recommended, because it is less quickly bitter than sulphate, the latter may be used if the former can not be secured. The addition of one-half ounce of powdered dry extract of licorice and 1½ tablespoonfuls of strawberry or raspberry sirup to the hot starch coating will make the baits more acceptable, but these materials are not necessary.

FORMULA IV. WATERPROOF WHEAT POISON.

Wheat	16 quarts.
Strychnine sulphate	1 ounce.
Water	1 gallon.

Dissolve the strychnine in 1 gallon of boiling water and pour it over the wheat, stirring until all the kernels are well wetted, then mixing it occasionally so that the moisture will be evenly distributed. After allowing the grain to stand for 12 or more hours, until it has absorbed all the water, place it in trays and dry it in the sun, not in an oven. Then return it to the mixing vessel, add 1 pint of melted mutton or beef tallow, and cook for about 25 minutes over a hot stove, stirring constantly. The poison is then ready for immediate use, or can be kept in a dry place as long as desired. The advantage of this preparation is that it is waterproof and will withstand heavy rains.

OTHER METHODS OF DESTROYING CHIPMUNKS.

If it becomes necessary to protect small areas from chipmunks after the animals can obtain such an abundance of seeds and berries that they refuse to take poison, they can best be shot or caught in steel traps or rat traps baited with bacon, grain, or other attractive food. But these makeshift methods of destruction are expensive, and the far-sighted man will destroy the chipmunks while poison is still effective.

CONCLUSIONS.

Chipmunks should be destroyed in this region, because they both damage crops and harbor young fever ticks. This may best be accomplished by the use of strychnine in flour-coated or tallow-coated wheat, but may be done at greater expense with the aid of guns and traps.

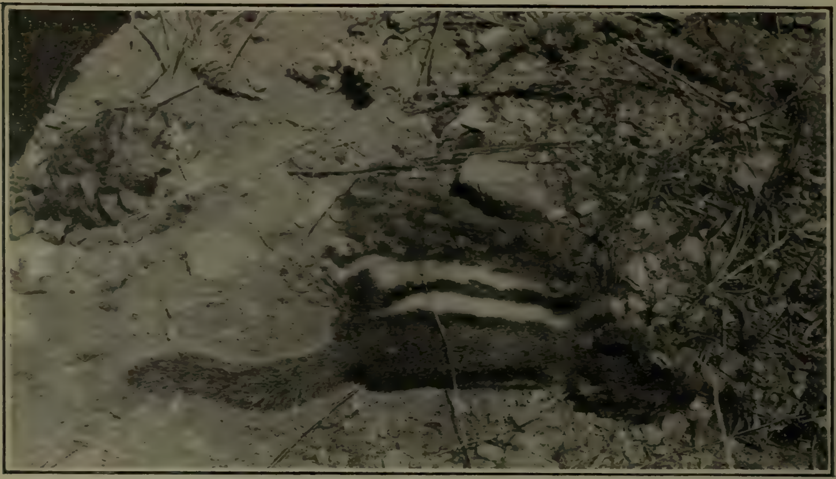


FIG. 15.—Side-striped ground squirrel killed by carrying poisoned grain in cheek pouches.

SIDE-STRIPED GROUND SQUIRRELS.

Side-striped ground squirrels (fig. 15), known also as rock squirrels, tiger squirrels, and two-striped chipmunks, occur throughout much of the rocky, timbered country of western Montana.

AS TICK HOSTS.

These striped ground squirrels are less important tick hosts than chipmunks only because they are not so generally distributed. Since they are very often infested with young fever ticks and have the chipmunks' habit of frequenting temporarily unoccupied log cabins, it is very important that war be waged against them in fever-infested localities. Young fever ticks were taken from more than half of those shot during these investigations, 45 being found on a single animal.

INJURY TO CROPS.

Side-striped ground squirrels damage crops in the same way as chipmunks, but their larger size and immense cheek pouches enable each animal to do a much greater amount of injury. One shot as it left a stable was found to be carrying 357 kernels of whole oats in its cheek pouches. (Fig. 16.)

HABITS.

These animals are true ground squirrels, as distinguished from chipmunks, and hibernate during the winter. In western Montana they usually "hole up" in September and reappear in March.

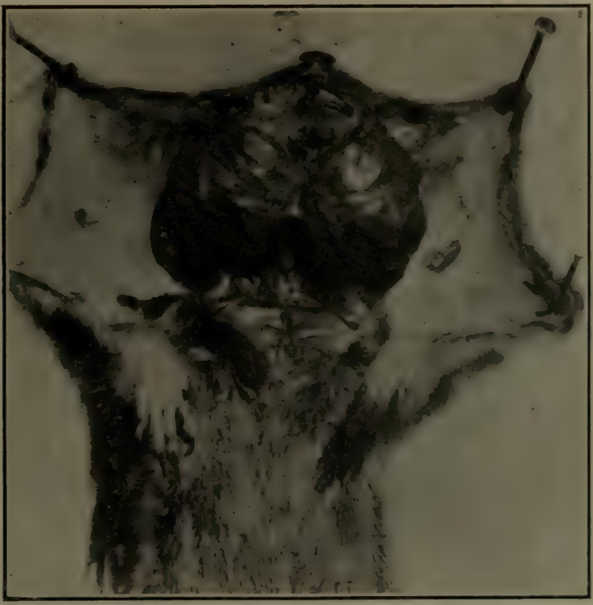


FIG. 16.—Dissection showing 357 kernels of whole oats in cheek pouches of side-striped ground squirrel.

In food habits the striped ground squirrel is intermediate between the Columbian squirrel and the chipmunk, for although it eats green vegetation freely, it is especially fond of seeds, grain, and berries. Unlike its bigger relative, it has immense cheek pouches and habitually carries food in them.

Probably this animal raises but one litter of young a year. The young, averaging about four to the litter, appear above ground during the latter part of May or early June.

POISONING SIDE-STRIPED GROUND SQUIRRELS.

Owing to the fact that these squirrels habitually carry food in their cheek pouches, they are very easily poisoned by baits coated with strychnine held in flour paste. When such baits are pouched the coating is dissolved by the mouth juices and the strychnine set free and then absorbed through the lining of the pouches directly into the blood. Very few of these animals poisoned by the writer have eaten any of the bait, practically all having been killed directly through the cheek pouches.

The baits recommended for chipmunks (Formulas III and IV) are both very effective against side-striped ground squirrels.

PINE SQUIRRELS.

INJURY TO CROPS.

Although pine squirrels (fig. 17) are abundant throughout the coniferous timber of western Montana, they do not as a rule cause any serious loss of crops. After the extensive forest fires of 1910, however, they attacked many of the apple orchards situated near the foothills along the edges of the Bitterroot Valley, doing considerable damage in some of them. A rancher living near Florence reported that his two boys shot 200 pine squirrels from the trees in a 5-acre apple orchard. So far as the author has been able to find out, these animals have never before seriously damaged apples in the Bitterroot, and it seems probable that they were driven to do so in the fall of 1910 by the unusual scarcity of their natural food, resulting from the great fires of late summer. Up to the 1st of September no damage of this sort was reported in 1911.

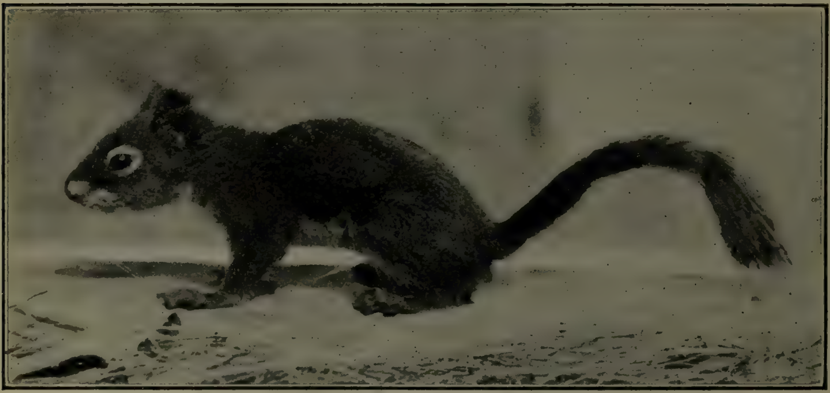


FIG. 17.—Young pine squirrel.

A less important sort of damage for which pine squirrels are responsible is the cutting off of the tips of numerous pine boughs. In thick stands of timber this damage is unimportant, but solitary trees are often seriously injured.

PINE SQUIRRELS AS TICK HOSTS.

Pine squirrels living in good " tick country " are almost always infested with young wood ticks, as many as 50 having been found on a single animal. It is therefore important that in fever districts these squirrels be destroyed, at least around ranches.

DESTRUCTION OF PINE SQUIRRELS.

As a rule, pine squirrels can easily be killed off by shooting; and they are readily caught in rat or steel traps baited with prunes, raisins, or pork. They are rather difficult to poison, but the strychnine " biscuits " recommended in Formula II should prove an effective pine-squirrel poison if used early in spring.

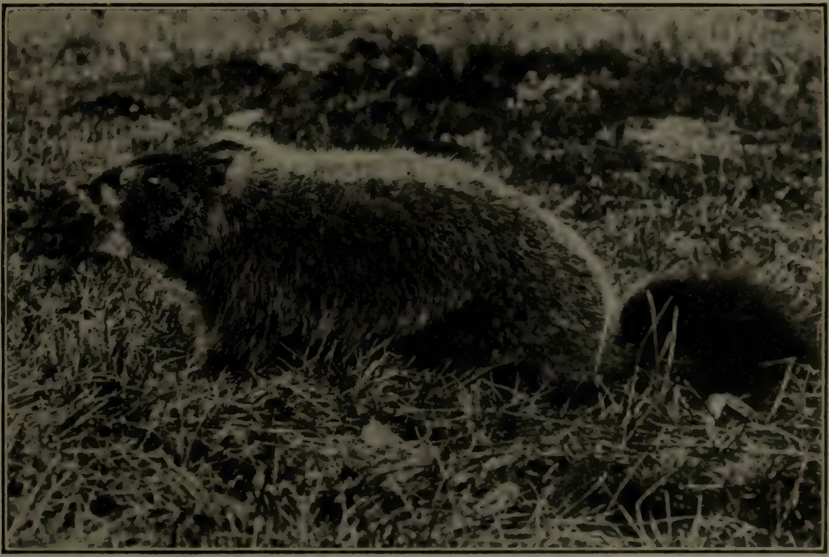


FIG. 18.—Woodchuck, which injures crops and spreads spotted fever.

WOODCHUCKS.

DISTRIBUTION.

Woodchucks (fig. 18), sometimes called " ground hogs," are locally abundant in rocky situations along the edges of valleys in many parts of western Montana. In the Bitterroot Valley they are especially numerous in rock piles and around abandoned buildings along the valley's edge. From one rock pile in a timothy field I took 15 woodchucks in 1910 and as many more in 1911; from under the buildings of an unoccupied ranch at least a dozen were secured during these two seasons, and in the stone wall surrounding a neglected orchard I estimated that there were at least 30 adult woodchucks.

HIBERNATION, BREEDING, AND FOOD.

Like the Columbian ground squirrel, woodchucks "hole up" in August and hibernate until the following March. The young, usually five in a litter, are born during the latter part of April and are out in full force and shifting for themselves by early June.

Woodchucks live almost entirely on green vegetation. Timothy, clover, alfalfa, dandelions, and numerous native plants are favorite foods.

INJURY TO CROPS.

Woodchucks are a serious nuisance wherever they occur near cultivated land. In hayfields they consume a very considerable amount of feed; and beans, carrots, potato vines, cabbage, and other garden truck are almost sure to suffer whenever woodchucks have access to them.

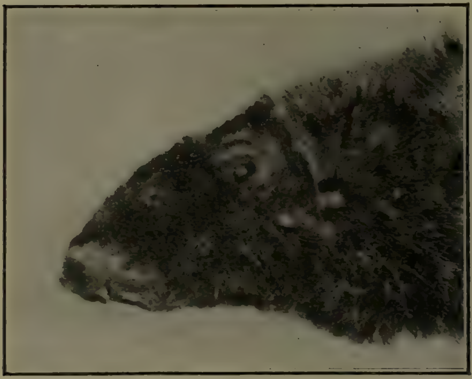


FIG. 19.—Partly engorged adult wood ticks on woodchuck.

WOODCHUCKS AS TICK HOSTS.

The woodchuck is of especial importance as a tick host, for it is one of the few native rodents on which the adult wood ticks feed until full of blood and ready to develop eggs. (Fig. 19.) It is also a favorite host of the seed and nymphal ticks, over 200 having been taken from one woodchuck. Moreover, this animal, when in captivity, is known to be susceptible to spotted fever, and there seems little reason to doubt that it is one of the species which helps to keep the disease alive. It is evident, therefore, that any campaign to eradicate ticks and control spotted fever should include an effort to lessen the number of woodchucks near cultivated land and pastures.

POISONING WOODCHUCKS.

A very inexpensive and effective woodchuck poison may be made by simply coating dandelion heads, clover, or alfalfa with thin starch or flour paste poisoned with powdered white arsenic, 2 gallons of the fresh green food being coated with a pint of cold flour paste containing 3 ounces of arsenic. As such a preparation both sours and wilts quickly, it should be mixed in the afternoon and in the evening placed at the entrances to woodchuck burrows, so as to be available when the animals first come out next morning. By one treatment with this poison the author killed all the woodchucks living under a shanty in a field where timothy and other green food were abundant.

TRAPPING WOODCHUCKS.

Although young woodchucks usually do not hesitate to step into exposed steel traps, older animals are more cautious. For this reason it is best to conceal the traps, covering them with paper and dust or with dry grass. If the traps are carefully set at the mouths of burrows, no bait is needed. Since woodchucks often spring traps with their breasts or bellies, and since their legs are short and slippery, it is better to use a rather large-sized trap. The number 1½ "jump" traps have been found excellent for this purpose.

FIG. 20.—Mouse refuge in holes left by burned stump and roots.

WHITE-FOOTED MICE.

DISTRIBUTION AND HABITS.

The white-footed mouse is probably the most generally distributed rodent in western Montana. It lives in every sort of country—under fallen logs, on sage-covered benches, on pine-covered slopes, in houses and stables, in dense forests, in grainfields, in damp meadows, and in dry fields. (Fig. 20.) The mice do not hibernate and are active even during the coldest nights in midwinter. They raise several litters of young each year, the average number in each being four or five.

They live principally on seeds, berries, and grain, and lay up quantities of food for the winter. Owing to their abundance they destroy considerable quantities of grain and berries, often carrying off and storing more than they eat on the spot. (Fig. 21.) They do great damage in nurseries and on forest sowing areas, where they dig up and destroy the seeds, this damage being so serious that no sowing can be successful where they are plentiful.

They are frequent hosts of young wood ticks and are of especial importance in fever districts because they frequently live in occupied houses and may thus be the means of bringing infected ticks into contact with man.

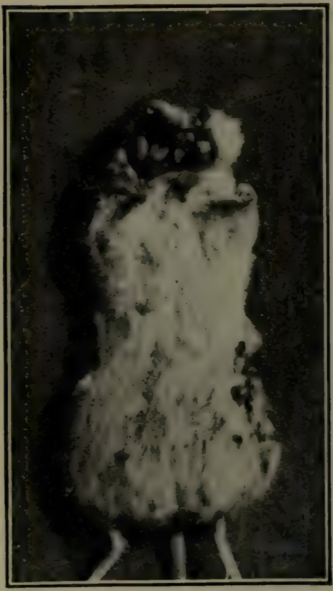


Fig. 21.—White-footed mouse killed by carrying 17 kernels of poisoned wheat.

POISONING WHITE-FOOTED MICE.

In most localities white-footed mice take poison readily and are easily killed by any of the baits recommended for chipmunks or ground squirrels. (See Formulas I to IV.) The poisoning must be done, however, in the spring or early summer, for after the various native seeds and berries ripen, the mice begin to store away their winter food, and poisoned baits are simply stored, not eaten. Thus while 13 dead mice have been found from a couple of dozen poison baits placed early in the summer, 5 bushels of poisoned wheat have been carried off by the animals in October without materially lessening their numbers. It is therefore evident that, though white-footed mice are easily killed in the spring and early summer, poisoning done after the native seeds and berries ripen is likely to be wholly useless.

HOUSE MICE.

These little gray mice, with their long hairless tails and small ears, are native to eastern Asia, but have been introduced by man into most civilized parts of the world. In Montana they are abundant in most of the large towns and are to be found on some of the outlying ranches. Although no ticks have been found on the few house mice examined, it is probable that these animals do occasionally serve as tick hosts, for they frequently live in infested fields.

Though not quite so easily poisoned as the native mice, they may usually be killed by either of the forms of poisoned grains recommended for chipmunks. (Formula III or IV.) Owing to the fact that house mice are sometimes able to eat out the centers of poison-coated kernels of wheat or groats, the tallowed grain described in Formula IV is best suited for poisoning them.

WOOD RATS.

Wood rats (fig. 22), called also pack rats and mountain rats, occur in the mountains and along the edges of valleys throughout western Montana. They are active only at night and do not hibernate. They are especially fond of tender green vegetation and berries, but readily eat seeds, grain, and table scraps.

AS TICK HOSTS.

Wood rats living in "tick country" are usually infested with young wood ticks; and this fact is especially important because infested animals often live in temporarily unoccupied dwellings. Two shot in one of the buildings of an abandoned railroad construction camp were fairly covered with seed and nymphal fever ticks, there being at least 100 on them. Many of these young ticks would have developed into adults in the buildings where the rats were killed; and, if one or both of the rats had had the spotted fever, it is quite possible that any person moving into the house might have contracted the disease.

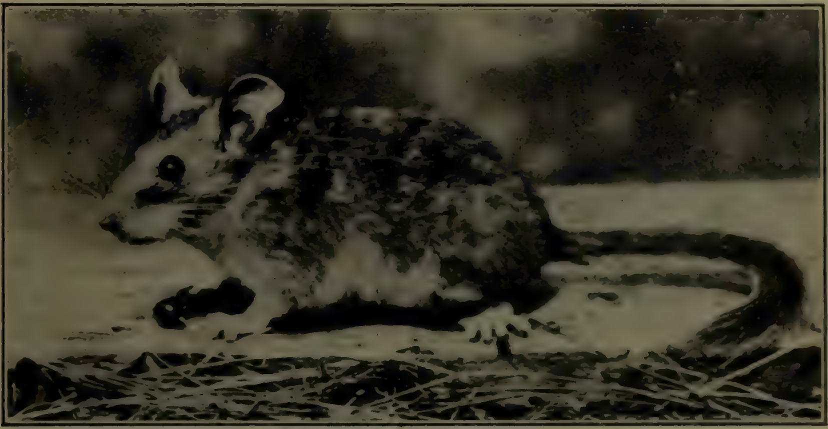


FIG. 22.—Young wood rat.

DESTROYING WOOD RATS.

Wood rats do not readily eat loose poisoned grain but can probably be effectively poisoned with "biscuits" made as described in Formula II, though only about half as much strychnine (1 ounce to 16 quarts of grain) is required for these animals.

A number of wood rats had been living for several years in the house mentioned in the woodchuck poisoning experiment described on pages 28–29, but after the treatment with arsenic-coated dandelion and clover heads not a single rat could be found. Although this is the only time the author has tried arsenic as a wood-rat poison, he believes that this inexpensive preparation will prove effective against the animals. Wood rats are easily caught in ordinary rat traps baited with prunes, raisins, or oatmeal.

MEADOW MICE.

DISTRIBUTION AND HABITS.

Three kinds of meadow mice occur in the valleys of western Montana, and another lives high up in the mountains; but since all three of the valley species may sometimes be found in the same hayfield, and since their habits are much alike, it is unnecessary here to distinguish between them. (Fig. 23.)

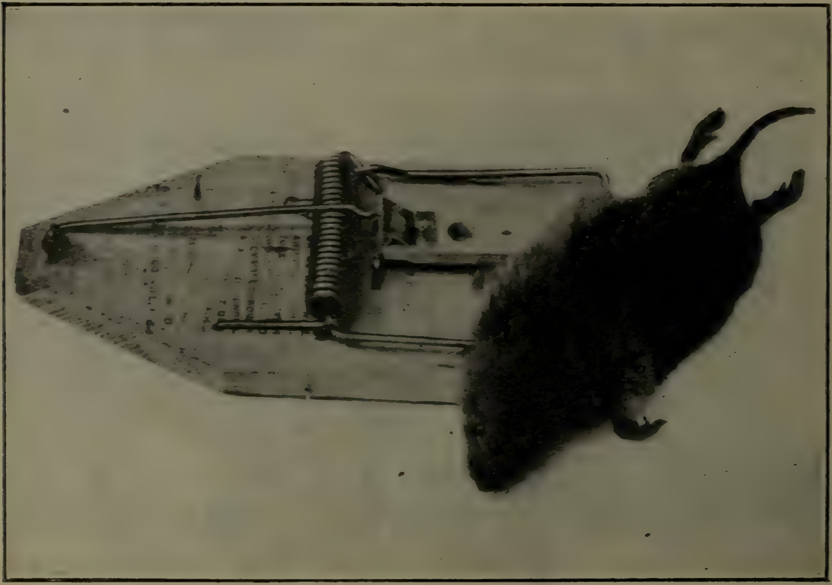


FIG. 23.—Meadow mouse caught in unbaited trap.

As a rule these mice occur only in damp fields and meadows where there is an abundance of grass. In such places their runways form networks on the surface of the ground, with occasional burrows leading to underground passages. Their nests are compact masses of dry grass, usually placed in rank vegetation or under fallen logs. Sometimes, however, the mice live underground, often among the roots of rotten stumps. (Figs. 24 and 25.) Several litters of young are born each year, the average number in a litter being six.

INJURY TO CROPS.

Under normal conditions meadow mice in hayfields do not very seriously injure the crop; but their nests are a continual source of annoyance when the hay is being cut, for they frequently clog the sickle bar. In cases where the mice suddenly increase enormously in numbers they may constitute a serious plague, as happened in Nevada in 1907, when they destroyed the alfalfa fields in whole valleys and caused a loss of several hundred thousand dollars. (Fig. 26.) To avoid the possible occurrence of such a plague, careful watch of these mice should be kept and any great increase in their numbers reported at once, so that repressive measures may be promptly taken.

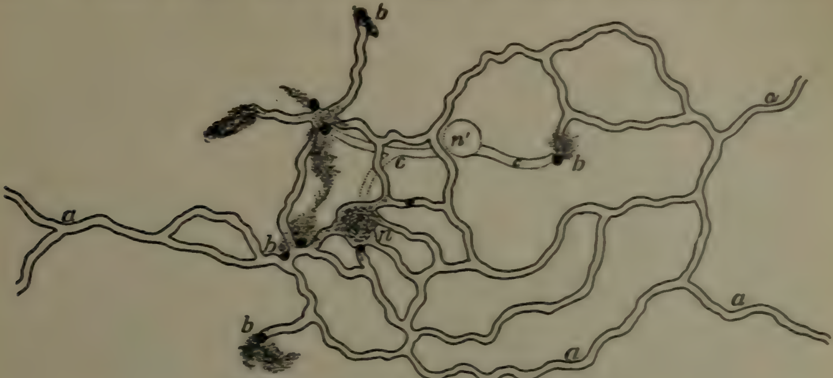


FIG. 24.—Diagram of meadow mouse runway.

Probably the most serious damage caused by meadow mice is in neglected orchards, in which rank vegetation affords ample shelter. (Fig. 27.) In one such orchard, containing 10 acres of 10-year-old trees, an examination of 243 trees showed that 32 per cent had been wholly girdled and killed, that 45.8 per cent had been partially girdled but not killed, and that

FIG. 25.—Mouse-infested stump in hayfield. A favorite shelter for meadow mice.

only 22.2 per cent were uninjured. A rancher living near Florence reports that during one winter the meadow mice killed 175 out of 1,000 five-year-old apple trees and that he has had to fight the mice ever since to keep them from killing more. Blackberry and raspberry bushes, when not kept cleanly cultivated, are often girdled by meadow mice.

POISONING MEADOW MICE.

Although damage to berry bushes and orchard trees can be avoided by clean cultivation, it is at times desirable to poison meadow mice. As these animals are much more fond of oats than of wheat, poisoned hulled oats are best for poisoning them. To be effective the grain preparation must be used early in the spring, as soon as the snow goes off. Groats prepared as recommended in Formula I, with the amount of strychnine reduced to 1 ounce to 40 quarts, should give excellent results. When groats are not available, crushed wheat may be used. One ounce of strychnine sulphate dissolved in 2 gallons of water should be sprinkled over and thoroughly mixed with the wheat.

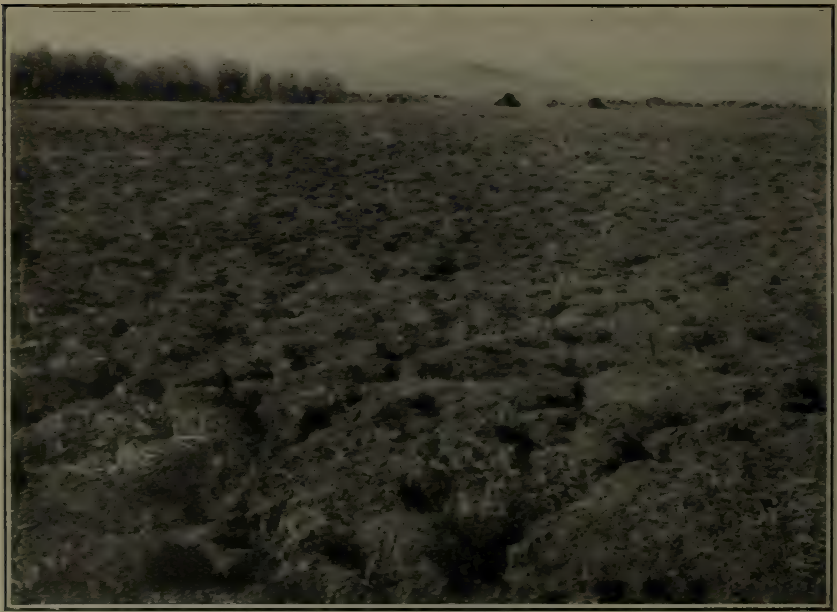


Fig. 26.—Alfalfa field ruined by meadow mice during Nevada mouse plague of 1907–8.

The following two preparations were very successfully used during the Nevada mouse plague, and there is every reason to think that they will be of equal value if used in the Northwest.

FORMULA V. GREEN ALFALFA.

Chopped alfalfa or clover	45 pounds.
Strychnine sulphate	1 ounce.
Water	1½ gallons.

Chop young shoots of alfalfa or clover into pieces 2 or 3 inches long. Dissolve the strychnine in half a gallon of hot water and add it to a gallon of cold water. Sprinkle this poisoned solution slowly over the alfalfa, mixing until the moisture is all taken up. Put a few pieces at a place along the mouse runways in the evenings or on cloudy days.

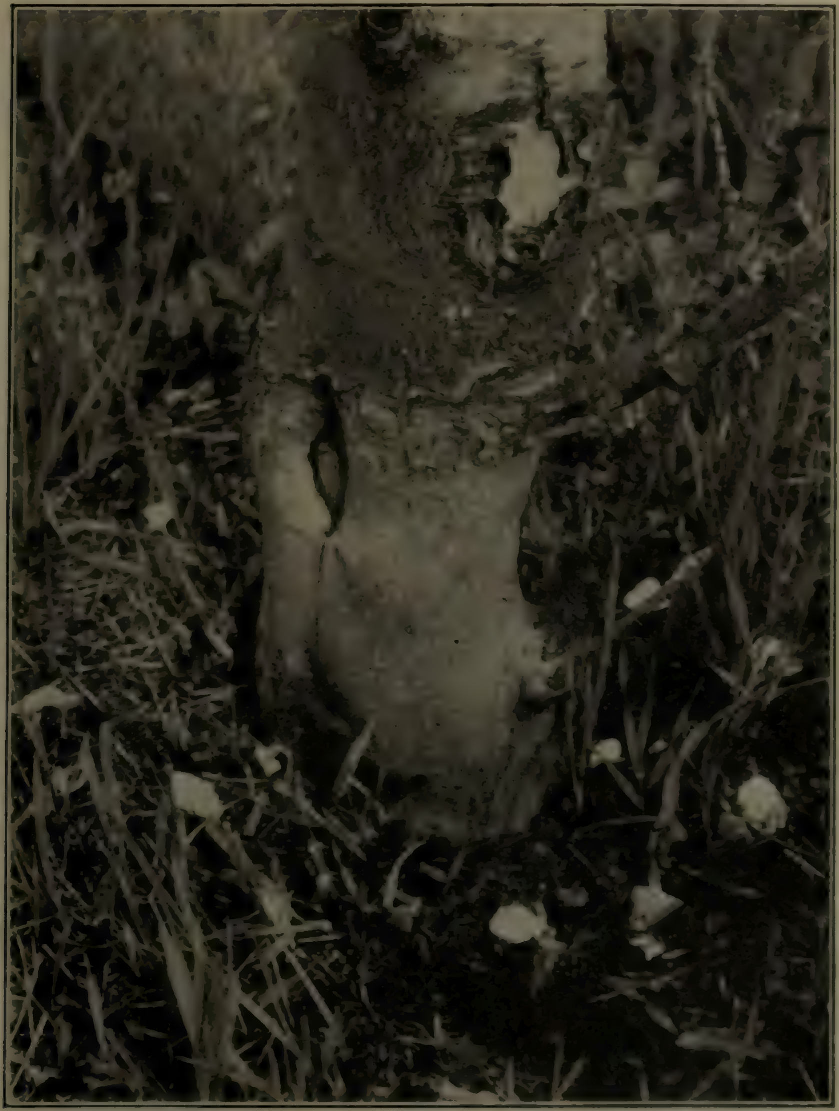


FIG. 27.—Apple tree killed by meadow mice.

Chopped dry alfalfa or clover hay or the fine material which gathers at the bottoms of stacks and haymows may be used during the winter instead of green hay, but in this case the following formula should be used:

FORMULA VI. ALFALFA HAY.

Chopped alfalfa (or clover) hay	30 pounds.
Strychnine sulphate	1 ounce.
Water	5 or 6 gallons.

The alfalfa or clover should be green rather than bleached, and chopped stems, rather than the blossoms and leaves, should be used, for they retain moisture longer.

Place the chopped hay in a large galvanized-iron washtub, sprinkle with 3 gallons of fresh water, and mix well with a pitchfork. Dissolve the ounce of strychnine in 2 or 3 gallons of hot water and sprinkle it over the dampened hay, stirring until all the poisoned solution is taken up. The bait is then ready for use. Since this preparation does not keep well, no more should be made up at one time than is needed for immediate use.

POCKET GOPHERS.

DISTRIBUTION AND HABITS.

Pocket gophers are numerous in western Montana, being especially abundant on ranches situated in the bottoms of valleys. (Figs. 28 and 29.)

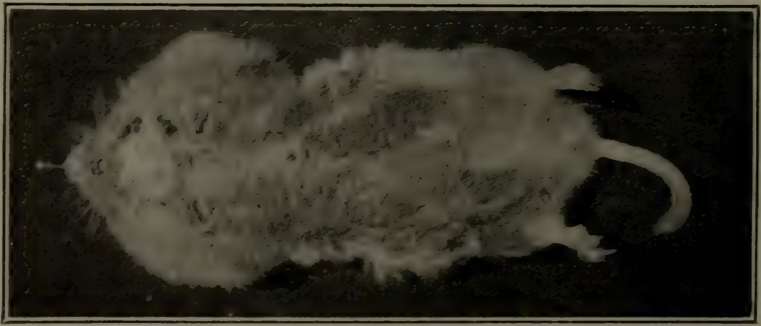


FIG. 28.—Pocket gopher with pouches full.

They spend practically all their lives in the underground tunnels which they excavate, and are seldom seen except when throwing fresh soil out of their burrows. They are not nocturnal, but are most active in the evenings and early mornings and on damp, cloudy days. The dirt excavated in making the tunnels is thrown out in little piles at irregular intervals, and the holes are then plugged up. (Fig. 30.) It seems probable that pocket gophers breed but once a year, the average number of young being four or five.

INJURY TO CROPS.

Gophers on a ranch are certain to be a more or less serious nuisance, for they injure irrigation systems, kill fruit trees, damage hayfields, and attack potatoes and other garden truck.

In many localities their most serious depredations are in young orchards, where they eat off the roots of trees just below the surface of the ground. (Fig. 31.) This damage is done mainly during the winter months, when green food is scarce, and often the first indication of the gophers' work is the toppling of the trees when the ground thaws in the spring. Apple, pear, and cherry trees are all attacked. A rancher on Lo Lo Creek, where pocket gophers are abundant, reports that in one winter they killed 60 out of 80 three-year-old pear and cherry trees planted the previous spring, and that they have since destroyed most of the remaining trees.

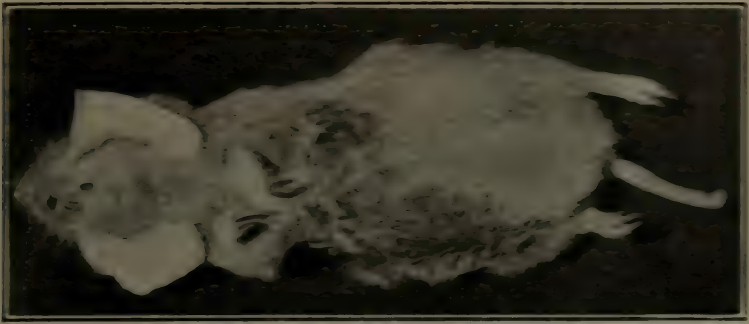


FIG. 29.—Pocket gopher with pouches turned inside out.

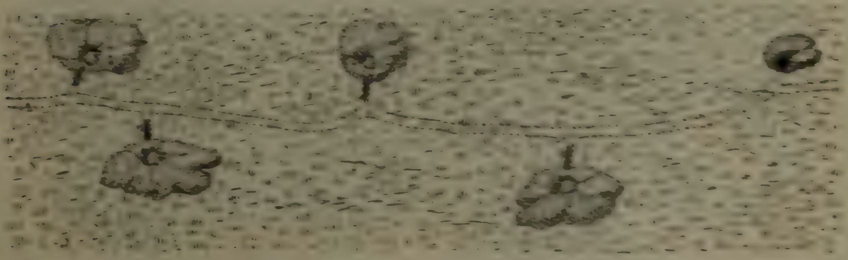


FIG. 30.—Double line of gopher hills. The dotted lines indicate position of main tunnel.

Although the gophers in hayfields live on roots of plants, the greatest damage is usually caused by the mounds which they throw up. (Fig. 32.) Single mounds sometimes cover a square yard or more of surface, and often whole fields are dotted with them. When the hay is being cut these mounds constantly interfere with the mower and by preventing close mowing cause the loss of much hay.

Gophers sometimes cause serious breaks in the main ditches of irrigation systems, but more often their burrows interfere with the smaller laterals and are thus an annoyance rather than a serious menace. The animals like to work in soft, damp ground, and find soil under the laterals well suited to their wants—with the result that, when water is again turned into these ditches, they are found to be obstructed by the gopher mounds or pierced by their burrows.

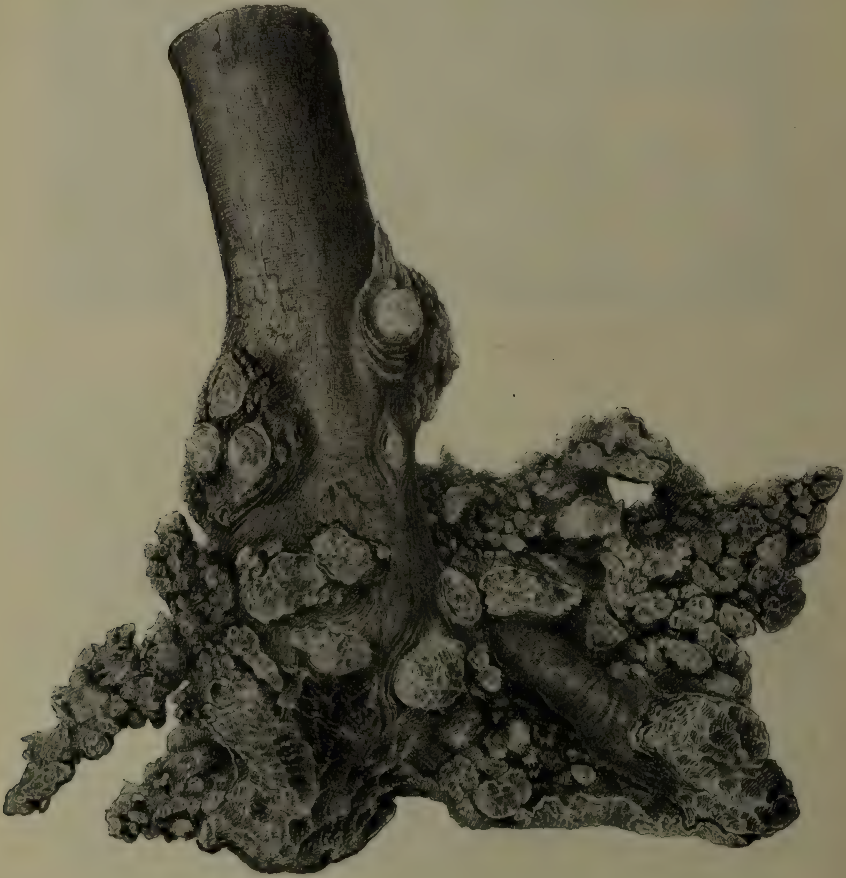


FIG. 31.—Stock of apple tree killed by pocket gophers.

Garden truck of various kinds is sometimes attacked by pocket gophers, and potatoes are often seriously damaged. Once while helping a rancher dig potatoes in Sanders County, Mont., the author found that a gopher burrow followed each row and that at least one-fifth of the potatoes had been taken.

POCKET GOPHERS AS TICK HOSTS.

Although one seed wood tick was taken from a pocket gopher secured in August, 1911, gophers so seldom serve as tick hosts and spend so much of their lives underground that their relation to spotted fever can not be considered of much importance.

POISONING POCKET GOPHERS.

These animals may be readily destroyed by either trapping or poisoning. Until recently the former method was the more effective; but, owing to investigations carried on during the fall of 1910 and spring of 1911 by T. H. Scheffer, of the Biological Survey, an exceedingly satisfactory method of poisoning the animals is now available. The following are Mr. Scheffer's directions for preparing and using the poison:

FIG. 32.—Pocket-gopher mound in wheat field.

FORMULA VII. POISONED VEGETABLES.

Sweet potatoes, parsnips, or carrots	8 quarts.
Medium starch or flour paste, cold	½ pint.
Strychnine alkaloid, powdered	⅛ ounce.
Saccharine	1/10 ounce.

Place the vegetables in a wooden pail or tub and with a sharp spade cut them into pieces about half an inch square. (Small quantities may be cut with a knife.) Mix the powdered strychnine into the paste and pour it over the chopped vegetables, stirring them until each piece is coated. Sulphate of strychnine may be used instead of the alkaloid if the latter is not available. If carrots are used the pieces should be spread and the outsides allowed to dry slightly before the starch is applied.

About a tablespoonful of this bait should be placed well down into the main tunnel at one or more points. This is best accomplished by the aid of a prod made from a hoe or broom handle, dull-pointed at one end and with a 15-inch piece of quarter-inch steel rod inserted in the other. The steel probe is used to locate the plugged-up lateral leading from a fresh mound, or the main tunnel between mounds; and the blunt-pointed end to enlarge the hole thus made. The opening, unless very large, need not be closed. After a runway has been poisoned the mounds along it should be leveled, so that new ones can be readily detected; and if no fresh workings are seen it is safe to conclude that the gopher occupying the run has been killed. With this method from 90 to 100 per cent of the gophers may be killed by a single treatment of the runs.

TRAPPING GOPHERS.

The old-fashioned steel traps are often used to secure pocket gophers, but they are unsatisfactory. If steel traps are to be used, "jump" traps are much the best for gophers. These traps should be set uncovered in the main tunnel, and the openings through which they have been inserted should be so tightly closed that no light can penetrate the run.

Several excellent traps designed especially for pocket gophers have been put on the market. These are set in laterals from which the trapper has removed the earth plug, and are designed to catch and instantly kill the gophers as they attempt to refill the holes. When these traps are used, the openings into the tunnel should not be closed. An old case knife makes an excellent instrument with which to locate and open up the dirt-filled laterals leading from the mounds to the main tunnel.

RABBITS.

DISTRIBUTION AND HABITS.

Three kinds of rabbits occur in western Montana—the jack, the snowshoe, and the cottontail.

Probably the most important of these three species is the jackrabbit, an animal characteristic of open sagebrush plains and benches. Its young are born fully furred and with their eyes open.

The snowshoe rabbit, though characteristically a mountain animal, occurs in the brushy and timbered parts of the colder valleys. Though much larger than the cottontail, it has proportionately shorter legs and ears than the jack. In winter it turns snow white, except the tips of the ears, which are jet black. The young, like those of the jackrabbit, are born fully haired and with their eyes open.

Cottontail rabbits are common in brushy areas of all the valleys, except those in the extreme northwestern part of the State. They are small and do not turn white in winter. Cottontails produce several litters each year, and the young, unlike those of the snowshoe and jackrabbits, are born with their eyes closed and their bodies hairless.

RABBITS AS TICK HOSTS.

All three species are often very badly infested with ticks, over 700 having been found on a single snowshoe rabbit. Fortunately, however, these ticks usually belong to species which seldom attack domestic animals or human beings and are therefore comparatively unimportant. Nevertheless a few adult fever ticks have been found on rabbits.

INJURY TO CROPS AND FRUIT TREES.

Rabbits often injure garden truck, hay, and growing grain more or less seriously, but the greatest damage which they cause in fruit districts is eating the bark of orchard trees. (Fig. 33.) This is usually done in the winter, when other food is covered with snow. Although apple and pear trees are most frequently attacked, cherry trees and others also occasionally suffer. Blackberry and raspberry bushes also are frequently injured. When the rabbits attack the bark of a tree they sink their big front teeth into it and pull it off in strips, sometimes repeating the process until large areas of bark are removed and the tree killed or seriously injured.

FIG. 33.—Apple tree injured by rabbits.

Although orchards are sometimes so badly damaged by rabbits as to require replanting, as a rule the depredations are not so serious. The following extract is from a letter written by the superintendent of an orchard company:

> The damage done by rabbits on the 1,000 acres planted amounted to about 3,000 to 3,500 trees out of a total of 130,192. On one special corner we had to replant 1,634 out of 1,971 trees.

RABBIT-PROOF FENCES.

Rabbit-proof fencing is one of the surest means of keeping the animals out of orchards and gardens, and is entirely effective except where drifted snow enables them to get over the fence. A netting of No. 18 or 20 galvanized iron wire, with 1½-inch mesh, and from 2½ to 3½ feet high is sufficient to exclude all rabbits. It may be used in combination with an ordinary wire fence. The lower edge of the netting should be turned outward for from 4 to 6 inches and covered with soil (with a plow); or a single closely barbed wire should be placed in contact with the surface of the ground.

TRUNK WASHES.

A large number of washes and paints designed to keep rabbits from eating the bark of trees have been tried, but most of them have proved utterly useless. Coal tar, pine tar, tarred paper, and various oils are likely to kill young trees; and while blood and animal fats are sometimes protective against rabbits when freshly applied, they are dangerous because attractive to meadow mice. Carbolic acid, though a favorite ingredient of these washes, evaporates so quickly that it is of no permanent value. The lime-and-sulphur wash so effective against the San Jose scale is probably the best and cheapest obtainable and, if thoroughly applied late in the fall, should remain effective throughout the winter. The following directions for its preparation and use are taken from an article by D. E. Lantz in the Yearbook of the Department of Agriculture for 1907:

Unslaked lime	pounds	20
Flowers of sulphur	do	15
Water to make	gallons	45–50

> A little salt [or glue] may be added to increase the adhesive property of the mixture. The lime, sulphur, and about a third of the water are boiled together for at least one hour, and the full quantity of water is then added. For San Jose scale the wash in the form of a spray is applied to the entire surface of the trees. For protection from mice and rabbits the trunks only require treatment, and the wash may be applied with a brush. One application in November should last the entire winter.

TRUNK WRAPPING.

The following directions for trunk wrapping are given by Professor Lantz in the article just mentioned:

> Mechanical contrivances for protecting young orchard trees are many. Where protection from rabbits only is required, woven wire netting is recommended. This should be made of No. 20 galvanized wire, 1-inch mesh, such as is often used for poultry netting. For cottontail rabbits rolls 18 inches wide are recommended, but as a protection against jackrabbits wider material is safer. The wire is cut into 1-foot lengths, and one of these sections is rolled into shape about the trunk of each tree, the ends being brought together and fastened at several places by means of the wire ends. No other fastening is needed. The wire is not in contact with the trunk and may be left on the tree permanently. It will probably last as long as the tree requires protection, and the cost of material need not be over 1¾ cents for each tree. For young evergreens, material of the same kind 1 foot wide and cut in 1½-foot lengths will give excellent protection.
>
> If trees are to be protected from both rabbits and mice, materials of closer mesh must be used. Wire window-screen netting is excellent for the purpose, and the cost, when permanence of protection is considered, is not great.
>
> Veneer and other forms of wood protectors are popular and have several advantages. When left permanently upon the trees, however, they furnish retreats for insect pests. For this reason they should be removed each spring and laid away until cold weather. While the labor of removing and replacing them is considerable, they have the advantage, when pressed well into the soil, of protecting from both mice and rabbits. They cost from 60 cents per 100 upward, and are much superior to building paper or newspaper wrappings. The writer has known instances where rabbits tore wrappings of building paper from the apple trees and in a single night injured hundreds of them. "Gunnysack" and other cloth wrappings, well tied on, are effective protectors. Cornstalks also furnish a cheap material for orchard protection. They are cut into lengths of 18 to 20 inches, split, and tied with the flat side against the tree, so as fully to cover the trunk.

POISONING RABBITS.

Probably the most effective rabbit poison is strychnine-soaked alfalfa or clover hay, prepared as recommended for meadow mice in Formulas V and VI. This should be placed in rabbit runs or in other places frequented by the animals, and the time chosen should be late fall, winter, or early spring, when the natural food supply is at its lowest. Vegetables and apples, poisoned as recommended for pocket gophers in Formula VII, or by inserting crystals of strychnine sulphate in slits made with a knife, are also effective. Great care must be taken to keep poisoned hay and vegetables out of reach of stock.

RABBITS AS FOOD.

Cottontail and snowshoe rabbits are excellent when properly cooked; and though old jack rabbits are tough and dry, the young are tender and well flavored. Rabbits should always be parboiled, no matter how they are finally cooked. They may be prepared in a variety of ways. A simple but excellent dish may be made by rolling each piece in seasoned flour or fine corn meal and frying in butter. They make good potpie when prepared like chicken. As stews, also, they are very palatable, and may be served with either brown or cream gravy. When rabbits are used for stews or pies it is well, after parboiling, to remove the meat from the bones.

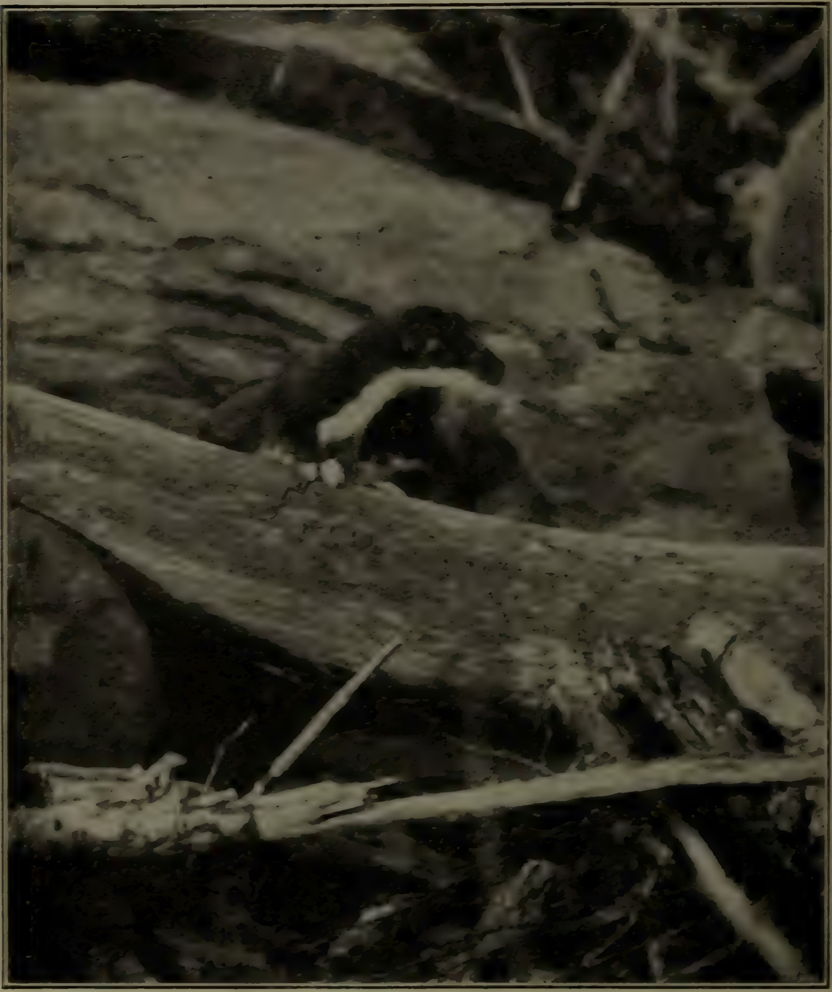


FIG. 34.—Weasel, an active enemy of harmful rodents.

BADGERS.

Badgers are common in many parts of western Montana. They live largely on Columbian and other ground squirrels, and their work may be seen in almost every squirrel colony. A badger which the author kept alive for several weeks during the summer of 1911 was very fond of these rodents and sometimes ate three or four of them in a day. It also ate woodchucks, chipmunks, pine squirrels, and mice. From a study of the food habits of these animals it is evident that they must destroy large numbers of rodents, but the large mounds which they throw up in digging out the squirrel burrows are so great a nuisance in cultivated fields that many ranchers consider badgers as much of an annoyance as are the animals which they kill. Moreover, the badger is one of the few hosts of the adult wood tick and, since it is a comparatively wide-ranging animal, probably carries ticks from one locality to another. Thus, while the badger is a valuable destroyer of rodents, it is hard to urge its protection as strongly in fever-infested regions as in localities where its importance as a tick host need not be considered.

WEASELS.

Weasels occur more or less commonly in most parts of western Montana. (Fig. 34.) They live almost entirely on live animals—mice, ground squirrels, rabbits, and chipmunks being favorite food. A weasel kept in captivity by the writer for several weeks was easily able to kill the largest ground squirrels placed in its cage. Since in a state of nature adult weasels undoubtedly kill many rodents, it is evident that the animals are a valuable aid in the control of these pests. Extensive trapping of ground squirrels with "hole sets" usually results in the capture of one or more weasels.

Although the weasel is frequently infested with ticks, these are of species harmless to man and domestic stock; and the animal's relation to the spotted-fever problem seems to be wholly beneficial.

BIG GAME ANIMALS.

MOUNTAIN GOATS.

Mountain goats frequently serve as hosts for large numbers of adult and young wood ticks. On three goats shot on Rock Creek near Lake Como, in May, 1910, there were over 300 wood ticks. But since goats are not abundant and occur only far back in inaccessible parts of the mountains, there is no need to lessen the protection now furnished them as game animals.

ELK.

Elk are now so scarce in the area infested with spotted fever that they can not bear any very important relation to that disease. No ticks were found on the only elk examined during these investigations.

DEER.

Although many hunters say that deer frequently serve as hosts for wood ticks, none were found on any of the six black-tailed or the two white-tailed deer examined during these investigations. There is no reason for removing the protection now granted these animals.

BEARS.

Black bears are common in the mountains in many parts of western Montana, and occasionally wander down into the bottom lands or cross from one range of mountains to another. Trappers say that bears are usually badly infested with wood ticks, and the author found a number on a brown bear shot near Woodman on June 30, 1910. Grizzly bears are much scarcer than black or brown bears and seldom leave the higher parts of the mountains.

COYOTES.

Coyotes are rather common throughout most of the western part of the State. Since they destroy sheep and poultry and frequently serve as hosts for adult wood ticks and are wide-ranging animals, it is important that their numbers be reduced as much as possible. This can best be accomplished by trapping, poisoning, and hounding. Full directions for destroying wolves and coyotes are given in Circular No. 63 of the Biological Survey.

SUMMARY.

Spotted fever is communicated from wild animals to human beings by the bite of infected wood ticks.

The most feasible ways of controlling the fever are: (1) To educate the inhabitants of infested localities in a belief in the "tick theory;" (2) to lessen the number of wood ticks, by (a) keeping domestic stock, the principal hosts of the adult ticks, tick free[1] and (b) lessening the number of native rodents, the necessary hosts of the younger states of the ticks; and (3) to destroy those native rodents which may serve as a source of continued reinfection of the ticks.

The destruction of harmful rodents in certain fever-infested parts of western Montana is doubly worth while, for there they not only are very destructive to crops, but are partly—probably fundamentally—responsible for the occurrence of the disease. Cooperation by all landowners in a district is essential to the success of any extensive campaign of rodent destruction. Poisons should be prepared in bulk by State experiment stations, counties, chambers of commerce, farmers' unions, or other organizations, and then distributed at cost to individuals.

By the adoption of these common-sense and comparatively simple methods there is every reason to believe that within a few years spotted fever in Montana will be practically a thing of the past.

---

[1] See Bulletin 105, Bureau of Entomology, U. S. Dept. Agriculture, 1911.

Issued March 12, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 485.

SWEET CLOVER.

BY

J. M. WESTGATE,
Agronomist in Charge of Clover Investigations,
Bureau of Plant Industry.

AND

H. N. VINALL,
Assistant Agrostologist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

C

U. S. SUPT. OF DOCUMENTS.
Apr. 7. 19.2

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 4, 1912.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript entitled "Sweet Clover," prepared by Mr. J. M. Westgate, Agronomist in Charge of Clover Investigations, and Mr. H. N. Vinall, Assistant Agrostologist, both of the Office of Forage-Crop Investigations of this Bureau.

The widespread discussion as to the merits and demerits of this plant has resulted in many conflicting statements regarding its value. Although frequently regarded as a troublesome weed, sweet clover seldom encroaches on cultivated land, while its value as a forage crop, as a soil renovator, and as a forerunner of alfalfa, in addition to its widespread utilization as a honey plant, makes it desirable to point out under what conditions its use is to be recommended and where its cultivation should be avoided, as well as to give instructions regarding the best methods of eradicating it when it is desired to utilize the ground in some other way.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction........ 7
Different species of sweet clover........ 8
  Ordinary white sweet clover........ 8
  Large yellow biennial sweet clover........ 9
  Small yellow annual sweet clover........ 9
History and present distribution of sweet clover........ 11
Adaptability of sweet clover to various soils and climates........ 12
Requirements for obtaining a stand of sweet clover........ 13
  Soils adapted to sweet clover........ 14
  Preparation of the seed bed for sweet clover........ 15
  Fertilizers for sweet clover........ 15
  Seeding sweet clover........ 16
  Inoculation of sweet clover........ 18
    The soil-transfer method of inoculation........ 18
    The pure-culture method of inoculation........ 19
  Treatment the first season........ 20
  Treatment the second season........ 20
  Need of experiments with sweet clover........ 20
Uses of sweet clover........ 21
Sweet-clover hay........ 21
  Time of cutting sweet clover for hay........ 22
  Curing and handling sweet-clover hay........ 23
Sweet clover as a soiling crop........ 24
Sweet clover as pasture........ 24
Sweet clover as a feed........ 26
  Palatability of sweet clover........ 26
  Composition of sweet clover........ 27
  Feeding experiments with sweet clover........ 28
Sweet clover as a soil improver........ 30
Sweet clover in rotations........ 31
Eradication of sweet clover........ 32
Seed production of sweet clover........ 32
Enemies of sweet clover........ 33
Sweet-clover production in different sections of the United States........ 33
  Sweet clover in Mississippi and Alabama........ 33
  Sweet clover in Kentucky........ 34
  Sweet clover in Utah........ 35
  Sweet clover in Colorado and Wyoming........ 36
  Sweet clover in Nebraska........ 37
  Sweet clover in the North-Central States (Iowa, Wisconsin, Illinois, Indiana, Ohio, and Michigan)........ 38
Summary and conclusions........ 38

ILLUSTRATIONS.

Page.

Fig. 1. Seeds and seed pods of three species of Melilotus........................ 8

2. Sweet-clover plant at the end of the first season's growth.............. 9

3. Sweet-clover plant near the close of the second season's growth......... 10

4. Sweet-clover roots showing enlargement at the end of the first season's growth.. 11

5. Portion of a sweet-clover plant showing flowers and different stages in the seed development.. 12

6. Map showing some of the localities where sweet clover is being utilized as a forage crop.. 13

7. Sweet clover on a steep slope along the roadside...................... 14

8. Row of sweet clover at Akron, Colo., showing proper stage for cutting.. 22

9. Sweet clover growing at Bellefourche, S. Dak......................... 23

10. Sweet clover in shocks for hay 24

11. Hogs pasturing on sweet clover in Iowa.............................. 25

12. Sweet clover arresting erosion in a gullied field in Kentucky.......... 34

13. Scene on a nearly worn-out farm in northern Kentucky................ 35

14. View of a cornfield where sweet clover was previously grown.......... 36

15. Sweet clover in shocks ready for the seed huller....................... 37

16. Sweet clover growing in practically pure sand in western Nebraska.... 38

B. P. I.—721.

SWEET CLOVER.

INTRODUCTION.

The sweet clovers (*Melilotus alba* and other species) are among the oldest of known plants, but only within comparatively recent years has their value for forage come to be recognized even locally in this country. The bitter taste of its foliage and the tendency of its stems to become woody when mature have caused sweet clover generally to be deemed of little value as a forage plant, because under ordinary conditions stock refuse to eat it unless they have been led to develop a taste for it.

This plant is known by a number of other names, among which the most common are Bokhara clover and melilot or Melilotus. It is also called bee clover, honey clover, mountain clover, and galygumber clover. When reference is made to the yellow-blooming species the term " yellow " is generally prefixed to the common name, but when no qualifying term is used the white species is the one usually meant. This usage is followed in the pages of the present bulletin.

The utilization of sweet clover should be accompanied by a thorough understanding of the somewhat peculiar requirements for success with this crop, as well as a knowledge of the conditions under which it may prove troublesome as a weed. It is of so much value when rightly utilized that its extension where it will not prove a menace should be encouraged by every legitimate means. Its value as a honey plant has long been recognized, but its efficiency in increasing the fertility of run-down soils is less widely known. Its utilization as a pasture, hay, and soiling crop is even yet practiced only locally throughout this country, but the extent of such utilization is steadily increasing. The fact that the bacteria on its roots are capable of inoculating alfalfa makes it a valuable crop to occupy the land immediately before seeding alfalfa. The sweet clover not only inoculates the soil but the large roots do much toward breaking up and aerating the subsoil, a condition which is very favorable to the growth of the alfalfa plants.

The tendency of sweet clover to occupy vacant land is noteworthy. It is often seen on vacant city lots and along roadsides and fence rows.

It does not usually encroach on cultivated fields nor on meadows that are regularly mown for hay. Stock often refuse to eat it at first on account of its bitter taste and strong odor, but when once induced to eat it by sprinkling it with brine or by other means they apparently relish it as much as any other forage and many animals show a preference for it.

DIFFERENT SPECIES OF SWEET CLOVER.

A great number of different species of sweet clover have been more or less utilized, especially in the Old World; but only three species are at all abundant in this country. These species (fig. 1) are the white biennial sweet clover (*Melilotus alba* Lam.), the large yellow biennial sweet clover (*Melilotus officinalis* Lam.), and the small yellow annual sweet clover (*Melilotus indica* All.).

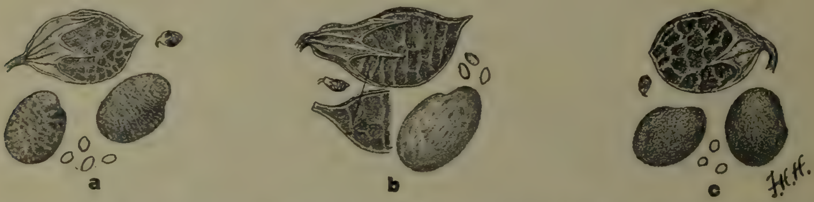


FIG. 1.—Seeds and seed pods of three species of Melilotus: *a, Melilotus alba* (white sweet clover); *b, Melilotus officinalis* (large yellow biennial sweet clover); *c, Melilotus indica* (small yellow annual sweet clover). The small figures in each drawing show the natural size of the seed.

ORDINARY WHITE SWEET CLOVER.

The ordinary white sweet clover is commonly referred to merely as sweet clover. When the yellow-blooming strains are meant they are usually referred to by the color of the flowers. Some progress has been made toward the development of less bitter strains of the white sweet clover, but these are not yet sufficiently distinctive to warrant trade names. The accompanying illustrations (figs. 2 and 3) indicate the general appearance of the white sweet-clover plant. It is an erect, stemmy, branching biennial plant with uniform, ascending stems not thickly supplied with leaves. During its second season it makes a growth of from 5 to 12 feet, produces numerous flowers, and dies when it has matured its seed. The first season it makes a growth of 18 to 30 inches in height and in addition stores up in a very large root reserve food material for a rapid and vigorous growth early the following season (fig. 4). When young the plant resembles alfalfa but can readily be distinguished by the bitter taste of its foliage. When in bloom it can easily be identified by the long, loose racemes of white flowers and its open coarser growth (figs. 3 and 5).

Unlike alfalfa the seeds are borne singly in each pod (fig. 1*a*). In common with other legumes it possesses the power of storing up nitrogen in the nodules on its roots, thus adding one important element of soil fertility to the land on which it is grown.

LARGE YELLOW BIENNIAL SWEET CLOVER.

The large yellow species is carried on the market under the name of yellow sweet clover. Like the ordinary white sweet clover it is a biennial. It is more spreading in habit and does not grow as tall as the white sweet clover, but attains a height of 3 to 5 feet. Owing to this more decumbent habit it is apt to be more of a pest in meadows, since the mower passes over a portion of the plant, which thus remains to produce seed and reseed the land. This species blooms one to two weeks earlier than the white sweet clover and is often used to supplement it for bee pasturage.

SMALL YELLOW ANNUAL SWEET CLOVER.

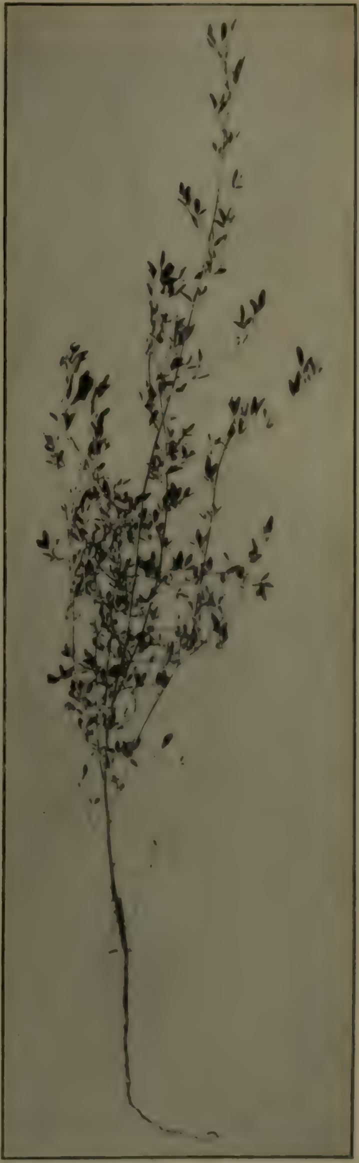


FIG. 2.—Sweet-clover plant at the end of the first season's growth.

The small yellow species is a low-growing, erect, early-flowering plant. It is only an annual, whereas the two species already described are biennials. It makes very little growth, at least in the sections where the other two sweet clovers are usually produced, and is not considered of much value. It is well thought of in southern California, but is not recommended for sections where the other species are perfectly adapted. Some confusion in the seed trade during recent years has been caused by the substitution of this small yellow annual sweet clover for the large yellow biennial sweet clover

(*Melilotus officinalis*). The differences in the seed and seed pods are indicated in figure 1. The Seed Laboratory of the United States Department of Agriculture, Washington, D. C., will identify samples of these different species at any time without charge. It will be noted that the seed of the small annual yellow sweet clover has a rough surface while the seeds of the other yellow species are smooth. This species makes a vigorous growth under subtropical conditions.

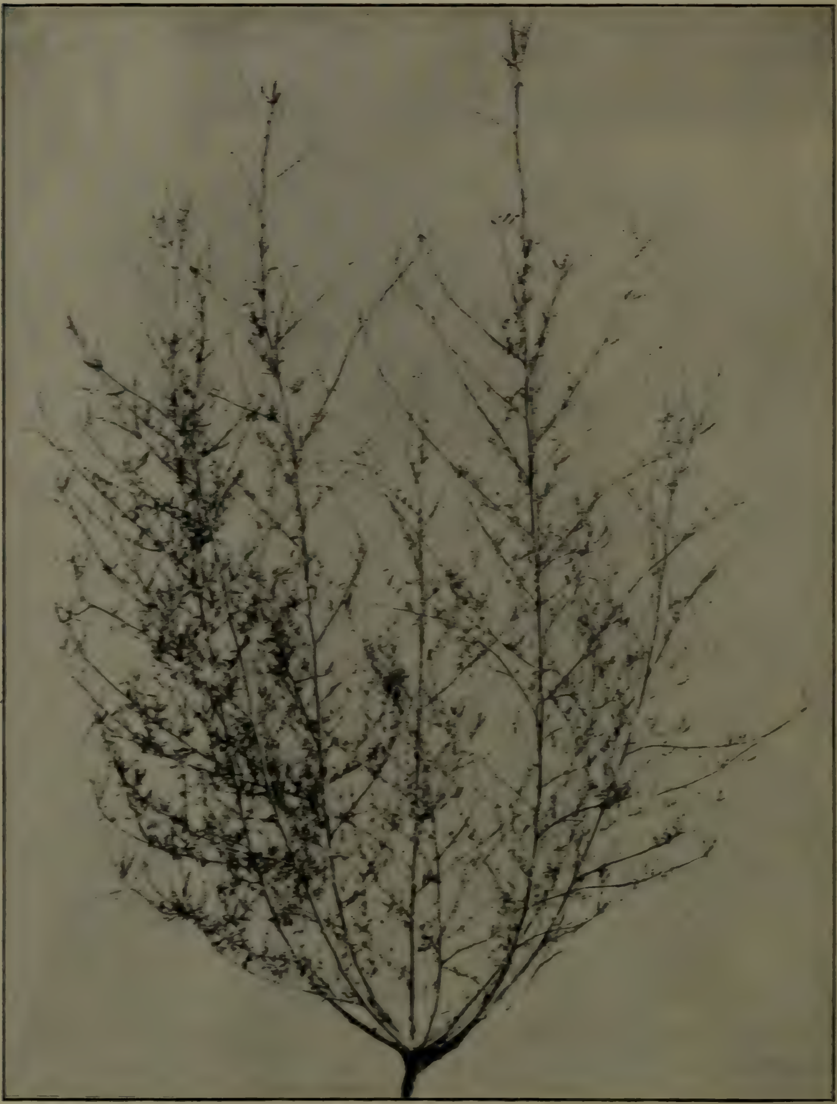


FIG. 3.—Sweet-clover plant near the close of the second season's growth.

HISTORY AND PRESENT DISTRIBUTION OF SWEET CLOVER.

The sweet clovers are natives of central Asia and have been known for more than 2,000 years to grow in the Mediterranean region of the Old World, where they have been utilized as honey plants as well as for forage and green manures. They are now distributed over the entire civilized world, usually occupying waste places not otherwise utilized. The white sweet clover was introduced into the United States by European colonists as early as 1738, but its value has not been recognized to any appreciable extent until within the last 20 years. It is at present grown extensively as a field crop in Alabama, Mississippi, Kentucky, and Utah, and locally on a field scale in Nebraska, Colorado, Wyoming, Iowa, Wisconsin, Illinois, Indiana, and Ohio. The accompanying map (fig. 6) indicates the sections where it has been definitely reported to be successfully utilized as a forage crop. It is looked upon as a troublesome weed in a number of States, especially in New York and in the irrigated States of the West, where it is spread over the alfalfa fields by the irrigating waters. The sweet-clover plants grow luxuriantly on the ditch banks and drop their seed into the irrigating ditches. The spreading of this plant into all parts of the country has been hastened by the seeding of it in waste places by beekeepers for the production of honey. This practice has often been condemned by those not interested in bees on the ground that the behavior of the plant is that of a noxious weed.

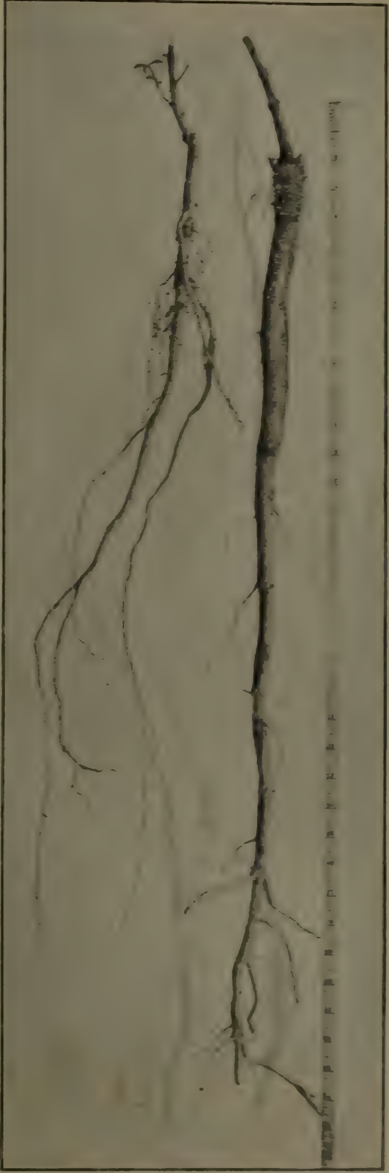


FIG. 4.—Sweet-clover roots showing enlargement at the end of the first season's growth. Buds for second season's growth already formed.

ADAPTABILITY OF SWEET CLOVER TO VARIOUS SOILS AND CLIMATES.

Sweet clover grows in all parts of the United States. It apparently possesses a wider adaptability in regard to soil types and climate than any of the true clovers and probably wider than alfalfa.[1] It succeeds in the extreme southern portions of the country and also grows vigorously in the Northern States, where it is called upon to endure great extremes of temperature. It thrives in the most humid parts of the country as well as in the semiarid regions, where the rainfall is but three-fifths of that required for the normal growth of such crops as timothy and red clover. It produces satisfactory crops on the "acid" soils of the Eastern States and also on the alkali soils of the West where sufficient alkali is present to prevent the growth of most farm crops. It will grow on soils too sandy to support ordinary field crops and appears to be even better adapted to raw clay and loess cuts and fills, where scarcely any other vegetation is able to establish a foothold (fig. 7). It also makes an excellent growth in gravel pits and stone quarries, but for some reason does not seem to do well on unsettled, cultivated soil. It makes its best growth where the soil is compact and not crowded with other vegetation.

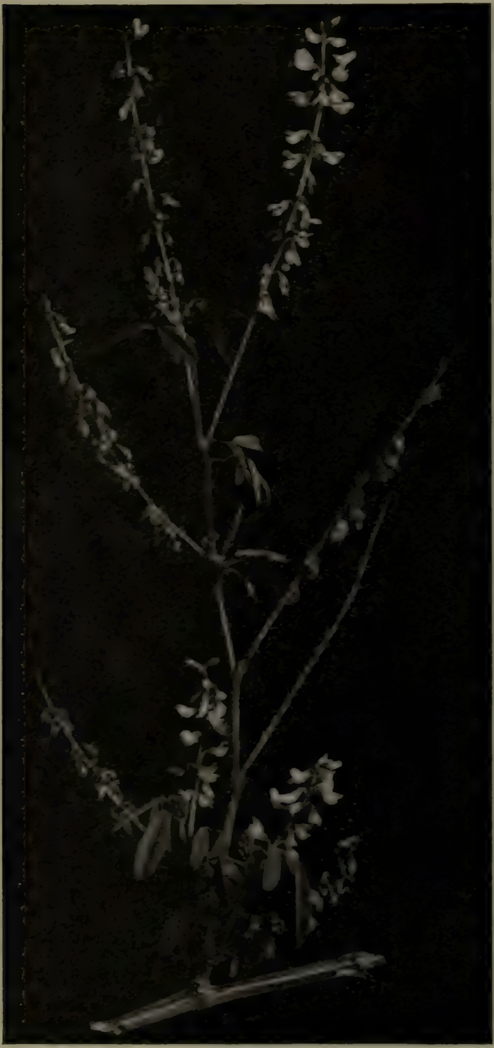


FIG. 5.—Portion of a sweet-clover plant showing flowers and different stages in the seed development.

---

[1] See Farmers' Bulletin No. 339, entitled "Alfalfa," by J. M. Westgate.

In such States as Iowa it seems to require a rich soil for satisfactory growth, but on the limestone hills of the Eastern and Southern States it makes a good growth on soils too poor to produce a paying crop of corn.

The adaptability of sweet clover to such an extreme range of conditions permits it to be recommended for utilization when the more valuable leguminous forage crops such as alfalfa and red clover[1] can not for any special reason be successfully produced. Its drought resistance makes it valuable for semiarid sections where irrigating water is not available, and in such of the Southern States as are characterized by occasional severe droughts it exceeds such plants as Lespedeza, or Japan clover, in ability to withstand these dry spells.[2]

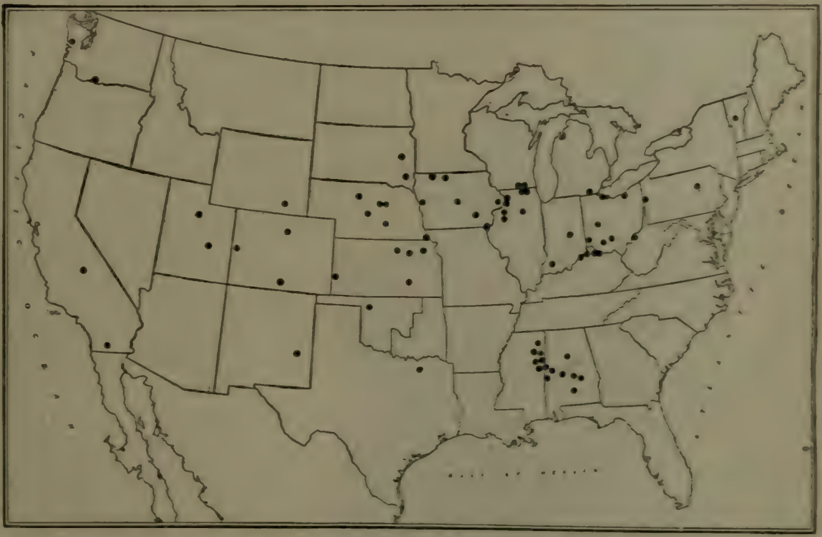


FIG. 6.—Map showing some of the localities where sweet clover is being utilized as a forage crop.

REQUIREMENTS FOR OBTAINING A STAND OF SWEET CLOVER.

A great many farmers have noted the luxuriant growth of sweet clover along roadsides and in other uncultivated places where it grows without any special attention, but have often been disappointed by obtaining a very inferior stand when seeding it upon cultivated land. For this reason it is necessary to look rather closely into the requirements for obtaining and maintaining a successful stand of this crop.

---

[1] See Farmers' Bulletin No. 455, entitled "Red Clover," by J. M. Westgate and F. H. Hillman, and Circular No. 80, Bureau of Plant Industry, entitled "Forage Crops for the Sand-Hill Section of Nebraska," by H. N. Vinall.

[2] See Farmers' Bulletin No. 441, entitled "Lespedeza, or Japan Clover," by A. D. McNair and W. B. Mercier.

SOILS ADAPTED TO SWEET CLOVER.

Almost any reasonable well-drained soil will grow sweet clover. It is more tolerant of poor drainage, overflow, and seepage conditions than alfalfa or red clover. In irrigated sections, especially where the reservoir system is in use, large bodies of land are apt to become useless for ordinary crops on account of the rising of the water table in the near-by fields. On such areas sweet clover has been observed to make a very vigorous growth. It is about equal to alsike clover in its ability to withstand poor drainage, but is less indulgent than either redtop (*Agrostis alba* Lam.) or slough grass (*Spartina michauxiana* Hitchc.). It makes its best growth on rich well-limed ground, but will make satisfactory growth on very poor limestone soils. It succeeds on newly exposed clay soils that presumably lack lime, but does not spread rapidly in clay soils outside of the limestone sections. When wanted for hay it will usually pay to seed it on fairly good soil, but for pasture the poorer fields of the farm can be made to yield returns that will justify the utilization of this crop upon them. Its value comes not only from the pasture obtained but also from the improvement resulting to such poor soils, especially if they be of limestone origin. After a few years in sweet clover, during which considerable pasture can be utilized, the ground will be brought into much better conditions for cultivated crops than it was before the sweet clover was established. Where not pastured too heavily a fair seed crop can often be obtained without seriously retarding the plant in its work of building up the fertility of the soil. On very poor soils the stand is often thin at first, but ordinarily

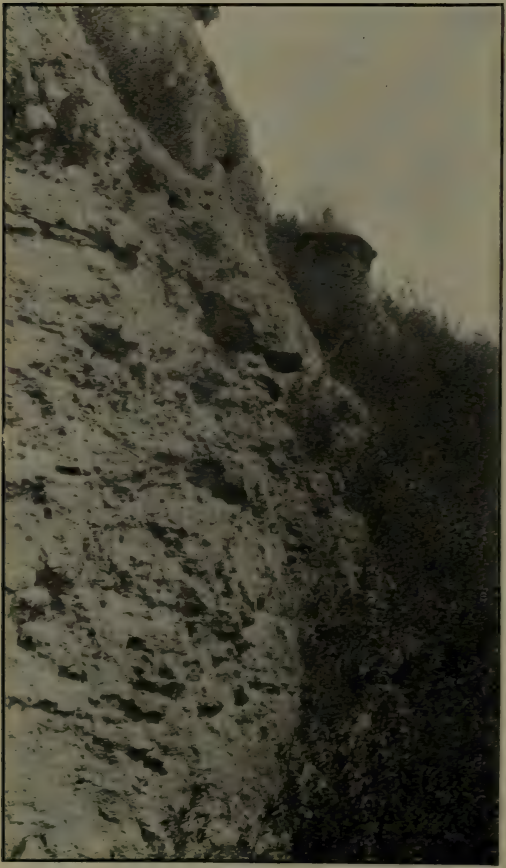


FIG. 7.—Sweet clover on a steep slope along the roadside.

it thickens up as the soil becomes richer and better able to support a good growth.

PREPARATION OF THE SEED BED FOR SWEET CLOVER.

Sweet clover requires a thoroughly compacted seed bed with just enough loose soil on top to enable the seed to be covered. The lack of a solid seed bed is probably the chief reason why sweet clover so often fails when seeded upon cultivated fields. The success of the crop on poor hills from which practically all the soil has been removed by erosion and on newly exposed clay areas where the ground is extremely hard and compact is thus explained. One field in northern Virginia sown on a loose seed bed heaved out almost completely in the spring of 1911. When a field which has been in cultivation is to be seeded to sweet clover it should be more thoroughly firmed and better settled than if intended for other crops. Plowing, if necessary, should be done several months before seeding, but it is usually best to seed on ground such as corn stubble that does not require plowing and depend on a disk, a turning and slicing harrow, or a spike-tooth harrow to cover the seed. In the East and South where the rainfall is abundant, it is well to roll the ground after seeding. Tests to determine proper dates of planting have indicated that successful stands can be obtained in Virginia by seeding either about the middle of May or the middle of August, and though it is possible that late winter seeding upon ground honeycombed by frost will prove practicable there is a lack of data on this point. The early germination rendered possible by such procedure seems to be in accord with the requirements for the best development of the plant during its first season's growth. Sweet clover has been seeded successfully with spring-sown grain as a nurse crop, but this method is probably open to some objection by reason of the somewhat loose, unsettled seed bed usually present under such conditions.

Seeding with a nurse crop of grain, however, contemplates the use of sweet clover in rotations and not as an individual crop. Where it is desired to obtain the maximum returns from the sweet clover itself in pasture, hay, and seed it is best seeded alone on a well-prepared but very firm seed bed. Then, if sown in early spring, it can be pastured with hogs or cattle the first year and the second year it may be expected to produce its maximum growth, furnishing both early pasturage and a hay or seed crop.

FERTILIZERS FOR SWEET CLOVER.

It is not usually necessary to apply any sort of fertilizer to the ground upon which sweet clover is to be seeded. Its success on the limestone hills, in stone quarries, etc., would seem to indicate the need of lime in the soil. Its successful growth, however, on soils that undoubtedly are deficient in lime shows that liming may not always be necessary. Sweet clover will probably respond favorably to the regular commercial fertilizers, but owing to the ability of this crop to succeed on many poor soils, especially those of limestone origin, it is probably the better practice to hold the fertilizer and apply it to the cultivated or money crops which follow the sweet clover. No information concerning the use of fertilizers on sweet clover in this country is available.

SEEDING SWEET CLOVER.

Under natural conditions the sweet-clover seed germinates for the most part in early spring, although a few seedling plants may also be observed in the late fall. Early spring seeding has been satisfactory in many sections, especially where the seed is sown on land not freshly plowed. When sown on ordinary cultivated fields sweet clover is usually sown later in the spring and often with a nurse crop of spring-sown grain. It has also been successfully seeded with such crops as fall wheat or rye, the sweet-clover seed being scattered in the spring in the same manner as red clover is frequently seeded. Fall seeding of sweet clover is also successful in regions of mild winters and can well be resorted to if it is desirable that the land be occupied through but one growing season. The lack of root development the first fall, however, reduces to some extent the growth of the crop the following season, and this may prove too much of a handicap to be offset by the other advantages. It usually requires 20 to 30 pounds of hulled seed and at least 5 pounds more of unhulled seed per acre. A lesser weight of seed would be sufficient were it not for the fact that often one-half of the seed has such hard seed coats that it does not germinate the first season and therefore is practically useless. This retarded germination of the hard seed can be overcome by soaking the seed in commercial concentrated sulphuric acid for half an hour. It should then be quickly washed, using running water if possible, as sulphuric acid becomes very hot when mixed with a small proportion of water. A great deal of water is therefore necessary in order to lessen the danger of burning. The seed should then be dried off quickly by spreading it out on a floor or canvas and stirring at intervals.

The acid corrodes or eats away the hard impermeable seed coat sufficiently to enable the seed to absorb enough moisture to germinate. This method has been investigated by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station, and by Dr. H. H. Love and C. E. Leighty, of the New York (Cornell) Experiment Station.[1] Tests made in the Department of Agriculture gave an increase in germination of 40 to 45 per cent. Great care must be exercised when working with sulphuric acid, as it burns the flesh and any wooden objects badly and is especially dangerous to have around in the presence of children. The vessels used for treating the seed should be of earthen or enameled ware to prevent corrosion by the acid. After the seed is treated it should preferably be sown promptly as it has a tendency to dry out after the coat has been eaten off by the acid, but it can be held for two weeks or a month under favorable conditions without any considerable deterioration. This method is still in the experimental stage and many details presumably remain to be worked out in actual practice. The imported seed is always hulled, while that grown in this country may not be hulled, owing to the fact that it is often gathered by hand locally and usually in a quantity too small to make it practicable to have it run through a huller. When starting a permanent pasture it is best to seed two years in succession at first, in order that there may be a number of 1-year-old plants ready to take the place of the 2-year-old plants which mature seed and die.

---

[1] Bulletin No. 312, Cornell University Agricultural Experiment Station, 1912.

Hard seed is present in nearly every sample, but is more abundant in southern-grown than in northern-grown seed. In commercial samples the proportion sometimes runs as high as 90 per cent. The lesser proportion in imported seed than in either the native northern or southern grown seed is possibly due to the fact that much of the imported seed is more than 1 year old. Table I shows the percentages of hard seed found in samples of sweet clover from different sources.

TABLE I.—*Percentages of hard seed found in sweet clover from different sources.*

Source of seed.	Number of samples.	Average per cent.	
		Germination.	Hard seed.
Southern	22	14	60
Northern	22	37	43
Imported	28	56	12

The following methods of obtaining a stand of sweet clover in northeastern Iowa are described in a letter from Mr. Frank Coverdale, of Delmar, Iowa:

> A field of grass sod should be plowed in the fall and disked as in preparation for a corn crop. The first week in May, 20 pounds of hulled sweet clover per acre should be sown and harrowed in well. This seeding may be done as soon as the ground is sufficiently dry early in the spring, but in this section best results have come when sown at the above date.
>
> Another good method of securing a stand is to sow it with some small-grain crop which can be taken off early in the summer. Barley or Early Champion

oats may be used as a nurse crop. When sweet clover is sown with such a nurse crop the young sweet-clover plants will be of considerable size by the time the grain should be cut. and on this account it is well to cut the grain as high up from the ground as possible.

Still another method is to take a small-grain crop off the land as early as possible. plow and disk immediately. and then seed the sweet clover not later than the last week in July. Plants from seed sown the second week in August have failed to live through the winter. but where there is plenty of moisture in the soil sowing the last week in July has resulted splendidly. Sweet clover acts very much the same as red clover and alsike: like them. if sown after August 1. it is likely in this latitude to fail to live through the winter. Even when sown as late as the latter part of July failure is likely to result unless there is plenty of moisture in the soil. This method. therefore. is not to be depended upon in a dry season. Seeding sweet clover in corn at the last cultivation gives fair results if the stand of corn is not too thick and rank in growth. This method. however. is not to be relied upon as a general rule and has not given very satisfactory results.

Everything considered, sweet clover does best when sown alone. For the very best results with this crop a fertile piece of ground should be selected. Limestone land is specially favorable for sweet clover. It is not absolutely necessary to utilize grass or clover sod, but it is necessary to have the ground reasonably rich and free from weeds if a strong stand is to be obtained.

After sweet clover is planted on a farm and the bacteria get established in the soil a stand will be less difficult to secure. When a few farmers first sowed this clover in this vicinity none succeeded in getting a catch. but this year almost all who used proper methods are succeeding in spite of the severe drought. My stand of sweet clover which was sown on sod land is all that could be desired. The sweet clover on the wheat land. however. is thin because the wheat sapped the moisture from the ground. Some of my neighbors inform me that sweet clover sown on oats has come through in good shape. There is more to the successful growth of sweet clover than most people think.

INOCULATION OF SWEET CLOVER.

It is apparently very essential that the sweet-clover plants be well inoculated if they are to produce satisfactory results. This inoculation is often naturally present. owing to the growth of sweet clover along the roadsides and in fence corners. Where the washing from such patches is distributed over the field the proper bacteria may be reasonably assumed to be in the field without further attention. In any event it is usually not difficult to use soil from around the roots of such sweet-clover plants for inoculating the field. Such a procedure is generally to be recommended.

THE SOIL-TRANSFER METHOD OF INOCULATION.

Inoculation by the soil-transfer method is generally more certain in its results than the pure-culture method. but where the soil is brought in from some outside locality not known to be free from noxious weeds. insect enemies, and plant diseases there is danger of introducing such pests.

The soil-transfer method consists in scattering over the new ground at the rate of 200 to 300 pounds to the acre soil from a healthy sweet-clover field, where the plants show an abundance of the tubercles on their roots. It is suggested that the seed be mixed with a small portion of the soil and the remainder drilled or scattered broadcast and immediately harrowed in. This should be done preferably on a cloudy day or toward evening, as the sun's rays are very injurious to the germs; but if the person who scatters the soil walks directly in front of the harrow the sun has practically no opportunity to harm the germs. To facilitate even scattering, the soil may be mixed with two or three times its own weight of ordinary soil obtained close at hand to save carriage charges.

A comparatively new method which, wherever tried, has given successful results, calls for the dampening of the seed and the spreading of it on a cloth, paper, or cement floor where an equal amount of soil from sweet-clover or alfalfa plants can be sifted over it. The dampened seed catches the soil and as soon as the seed is sufficiently dry to sow it should be seeded. This has the advantage of requiring only a small amount of soil and apparently assures satisfactory results. Another method is to make a soil solution of the inoculated soil and dip the seed in this before sowing.

THE PURE-CULTURE METHOD OF INOCULATION.

The pure-culture method, though considerably less certain than the soil-transfer method, has the advantages of greater ease of transportation and freedom from danger of introducing harmful pests upon the farm. The method of inoculation by pure cultures may be carried out in either of two ways: (1) A bottle of pure culture of the proper kind of bacteria is opened and the culture mixed with a convenient quantity of water; this diluted culture is now thoroughly mixed with a considerable quantity of soil, preferably from the field where the legume is to be sown; the treated soil is then distributed in the same manner as when inoculation is made by the use of soil from an old field; (2) a pure culture of the proper kind of bacteria is prepared according to the directions accompanying the bottle and is then applied to the seed in such a way that all of the seed may be moistened, though not soaked. The seed should be planted as soon as practicable after this treatment—that is, as soon as it is sufficiently dry for convenient handling. Drying may be facilitated by adding dry, sifted earth, preferably from the field in which the leguminous crop is to be grown. The nodule bacteria very often die within a week after the seed is inoculated and dried; it is therefore highly desirable that the inoculation be made the same day the seed is sown. Inoculated seed should never be dried in the sun.

TREATMENT THE FIRST SEASON.

When seeded in the spring without a nurse crop no special treatment is required the first season, unless it is necessary to cut back any weeds which threaten to choke out the sweet-clover plants. This clipping should be at a height of 5 or 6 inches and will induce the sweet-clover plants to stool out instead of producing a slender plant the first season. The stand may be pastured during the first summer and in the fall until a number of killing frosts have occurred. If the pasturing is not sufficient to keep the young plants eaten back a cutting of hay should be made when the growth ceases in the fall. It is apparently not necessary to allow any of the top growth to remain on the plants when they go into the winter.

When seeded with a nurse crop such crop may be cut for grain if the moisture conditions are favorable, but if an untimely drought threatens the life of the sweet-clover plants the crop should be cut for hay. In the South a good hay crop or late summer pasture may be obtained the first season even when sown with a nurse crop, but in the North a small amount of late pasture only is usually available.

TREATMENT THE SECOND SEASON.

One of the special advantages of sweet clover is its very early growth in the spring, producing good pasturage before other pasture crops have commenced growth. In the North it will furnish a good hay crop in the latter part of June and a second crop of hay or seed in the late summer. In the South two crops of hay and one of seed may be harvested the second season. After maturing seed the plant dies, even though it be only the first cutting of the second season's growth that is allowed to mature seed. Sweet clover may also be pastured the entire season, and if not pastured too heavily will reseed itself for succeeding seasons. It is often a desirable practice to mow off the heavy growth so as to induce new growth which will be more readily eaten by the stock. If this is done narrow strips of uncut plants should be left at intervals for the purpose of reseeding the pasture.

NEED OF EXPERIMENTS WITH SWEET CLOVER.

Many points in connection with the production of sweet clover yet require experimental determination. Needed knowledge can best be gained by a comparison of the relative merits of different practices, so that questions regarding specific points may be definitely answered. The special requirements of the sweet clover on any particular soil type or in any particular section is a matter which must usually be determined by direct experiment. By devoting a small section of the field to experimental purposes these needs can readily be determined. Among the points which can be experimented with on narrow strips across one end of the field are: Time of seeding, rate of seeding, and the merits of a nurse crop as compared with no nurse crop. At right angles to the narrow strips upon which the different times of seeding, etc., are being tried it is entirely practicable to apply different amounts of lime in order to determine the effect of different rates of application of lime upon each of the other experiments being tried. Later in the season strips across the regular field may be cut at different stages of growth to determine the effect on the suceeding crops of hay or seed. In all such experimental strips it is important to provide a check strip to be given only the customary treatment. This will serve as a basis of comparison for the different treatments given on the experimental plats. The combination of methods giving the most promising results can be applied to a much larger acreage the succeeding season.

USES OF SWEET CLOVER.

The nature of sweet clover permits of its being utilized in a number of different ways. For forage purposes it may be used as hay, as ensilage, as a soiling crop, or as pasture for all classes of live stock, which may be readily taught to eat it. It may also be used as a green-manure crop.

It is especially valuable as a honey plant, furnishing nectar for bees over a long season. It is often seeded in waste places for bee pasture and is the only plant now known to beekeepers which can be utilized in this way with profit. The honey made from sweet clover is darker than that from white clover and has a decidedly greenish color. When it is unmixed with other honeys the flavor is not usually considered the finest, but it is usually found mixed with white clover, alsike, alfalfa, or other honeys, in which case the characteristic flavor is pleasing. Blooming as it does after the white-clover honey flow, sweet clover is a valuable asset to the beekeeper. Of recent years sweet-clover honey has appeared in considerable quantity on the market from various parts of the country. Its utilization as a honey plant dates from remote antiquity and to this feature of the plant is due the name "Melilotus," which means honey lotus or honey plant.

It was also used by the ancients in medicines, and to a certain extent this use is continued to the present day. Its utilization as a forage crop and as a soil improver will be considered more in detail.

SWEET-CLOVER HAY.

In the absence of more valuable forms of hay sweet clover may be utilized for feeding all classes of live stock. In the North one cutting is usually possible the first season, especially if seeded without a nurse crop, and two cuttings may be obtained the second year. In the South two cuttings the first season and three cuttings the second season are ordinarily possible. The Massachusetts State Experiment Station seeded a plat of sweet clover May 8 and on September 9 it was cut, yielding cured hay at the rate of 2,700 pounds per acre. The following season a cutting was made on June 24, yielding at the rate of 2,727 pounds per acre, and on September 22 a second cutting yielded at the rate of 1,000 pounds per acre. At the Canebrake substation, Uniontown, Ala., in 1904, the first year's seeding of sweet clover produced hay at the rate of 5,056 pounds per acre, and in 1905 the second season's crop was 6,320 pounds per acre. Another plat produced 6,672 pounds per acre in 1903 and 7,048 pounds per acre in 1904. At the Utah Experiment Station in 1892 sweet clover made more than double the yield of any of the clovers or grasses with which it was compared.

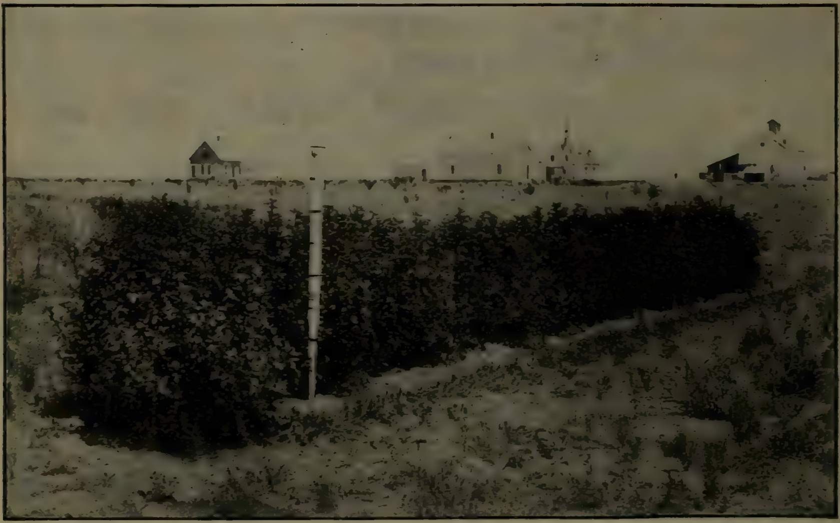


FIG. 8.—Row of sweet clover at Akron, Colo., showing proper stage for cutting. Annual precipitation approximately 19 inches.

TIME OF CUTTING SWEET CLOVER FOR HAY.

The first season's growth does not usually get coarse and woody and should be cut when it shows its maximum growth in the fall. It is not necessary to allow time for any second growth to come on before cold weather. The second season it is necessary to cut the hay before the first bloom buds appear, since after this stage the plant rapidly becomes coarse and woody and much less palatable to stock. (Figs. 3, 8, and 9.)

CURING AND HANDLING SWEET-CLOVER HAY.

When cut before blooming, the plants are rather succulent and hard to cure. In this respect it is often harder to cure properly than either alfalfa or clover, since by the time the large succulent stems are cured the leaves are very apt to shatter. The shattering of the leaves should be avoided, as the leaves constitute the best portion of the hay. The mower may be started in the morning as soon as the dew is off and the hay raked into windrows just before the leaves become dry enough to shatter. After allowing it to remain a day in the windrow it may be put into shocks and cured (fig. 10). These shocks should not be so large that they can not be thrown on the rack entire by the pitchers. If too large, the shocks must be torn apart when pitched on the rack, and this will result in a considerable loss of leaves. Sweet clover is not difficult to cure in the shock, and instances have been observed where it was shocked up perfectly green, in which condition the leaves dried so as turn water very readily.

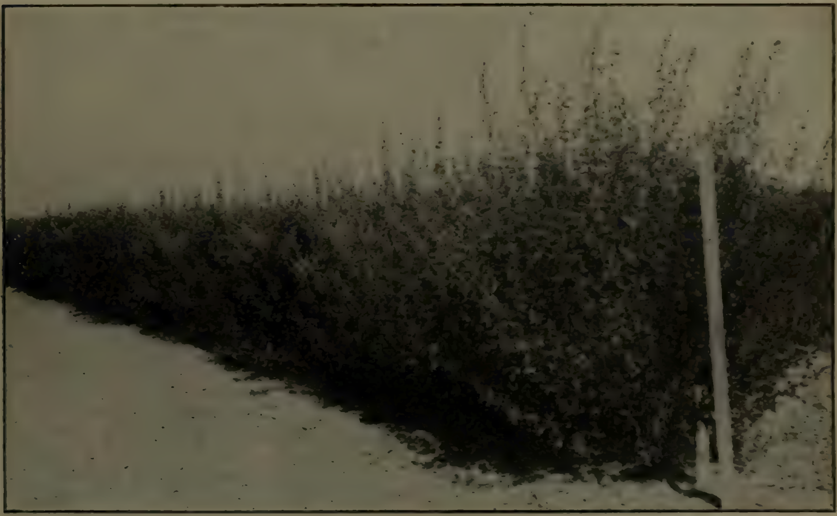


Fig. 9.—Sweet clover (S. P. I. No. 16289) growing at Bellefourche, S. Dak. Plants 6 feet high; annual precipitation approximately 16 inches.

Another method of haying is to cut two or three hours in the afternoon, stopping when the dew commences to fall; the plants then remain practically green overnight and the dew on top of the swath soon dries off in the morning, thus allowing nearly a full day for drying in the swath before starting the rakes in the afternoon. The hay may be stowed away in barns, but it is usually stacked. Some sort of foundation for the stack is always desirable to prevent the loss of the hay which otherwise would come next to the ground.

Some kind of covering for the stack should also be provided, either in the form of a roof, a canvas, or long-grass hay placed on top. If none of these means is practicable, a topping of perfectly green sweet-clover hay will cure with the leaves flat and turn most of the water. It is well known that hay made from either red clover or alfalfa will undergo spontaneous combustion if put into the barn with too much external moisture upon it. No instances of spontaneous combustion of sweet-clover hay have been reported, but this may be due to the fact that comparatively little sweet-clover hay is mowed away in barns. The same precautions should therefore be taken with sweet clover as with red clover or alfalfa hay.

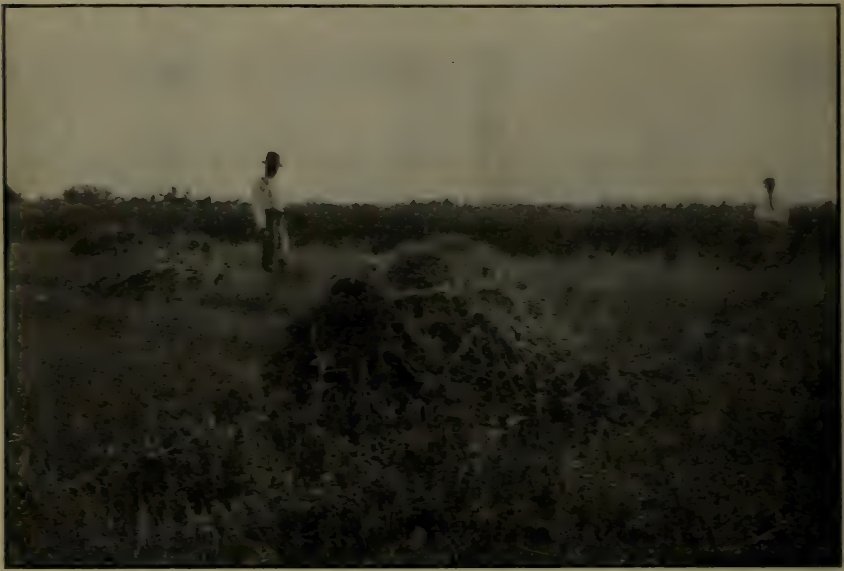


FIG. 10.—Sweet clover in shocks for hay.

SWEET CLOVER AS A SOILING CROP.

When cut green and fed to cattle the sweet clover is usually less palatable than when fed as hay, although numerous instances have been noted where the freshly cut green feed has been readily eaten by stock. As a soiling crop it is best adapted for feeding to hogs. At the Ontario Experiment Station over 30 tons of green feed per acre were obtained in a single season.

SWEET CLOVER AS PASTURE.

Sweet clover makes excellent pasture for horses, sheep, cattle, hogs, and chickens (fig. 11). Probably the easiest way to create an appetite for the plant is to commence pasturing the stock on it very early in the spring before other green feed has started. A sufficient number of animals should be kept on it to keep it eaten down close so that at all times there will be an abundance of fresh shoots for grazing purposes. An acre of sweet-clover pasture will ordinarily support 20 shoats, in addition to furnishing a light cutting of hay. For the best growth of the hogs, however, a pound of grain per hundredweight of the stock per day should be given. When pastured on the first season's growth of sweet clover it is well to place rings in the hogs' noses to prevent them from digging up the roots of the young plants. Grazing appears to be beneficial to the plants in that it induces stooling.

Stock when pastured upon sweet clover make gains which compare very favorably with those obtained from either alfalfa or red clover. The advantage which sweet clover has over the crops just mentioned is that it will grow on some soils too poor in humus for the successful production of either alfalfa or red clover. A few cases of bloating of cattle have been noted when they were pastured on sweet-clover fields, but these cases are much less frequent than on red-clover or alfalfa fields. The best method of avoiding the slight tendency to bloat is to refrain from turning the stock on the sweet clover when it is wet with dew or rain or when the animals are unusually hungry for green feed. Most of the grazing of sweet clover is confined to regular pastures, but in an increasing number of localities roadside grazing is becoming common. In several sections sheep are reported to have obtained valuable sustenance from grazing on sweet clover, especially during droughts when the ordinary pastures were dried up. It is doubtful whether sweet clover will ever do more than supplement other pastures. Its chief advantages are its

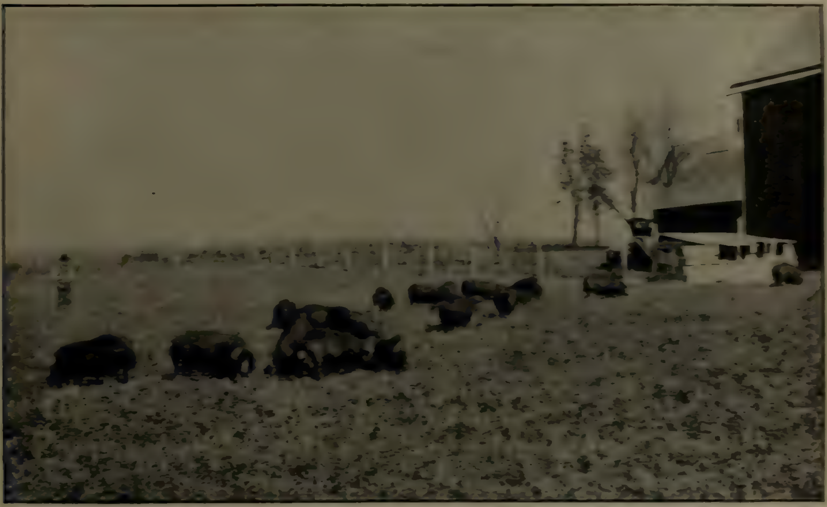


FIG. 11.—Hogs pasturing on sweet clover in Iowa.

ability to grow on and build up poor soils, to survive the midsummer droughts which frequently occur throughout the country, and to produce early and late pasturage.

SWEET CLOVER AS A FEED.

PALATABILITY OF SWEET CLOVER.

The chief drawback to the utilization of sweet clover is its bitter taste due to cumarin, which causes animals at first to refuse it. In this respect, however, it is only fair to the sweet clover to note that stock will often refuse to eat a number of valuable leguminous forage crops when first offered to them. Milk cows have been observed to refuse an entire ration of alfalfa hay even when no other feed was available at feeding time. This, however, was when it was first introduced to them. Shippers of cattle from the arid sections of the West, where corn is unknown, often have difficulty in getting the stock to eat corn fodder or even corn. One specific instance has come under observation where the cattle were fed corn with the dried husks attached, whereupon they ate off the husks and left the corn uneaten. When these same cattle were turned on the green grass the following season instead of eating the new growth they contented themselves with browsing off the dead stalks of the preceding season's growth, which presumably more closely resembled the desert grasses to which they were accustomed. Preliminary experiments with leguminous crops, even at the hands of careful experimenters, can not always be taken as final. In this connection it may be mentioned that when cowpeas were first tried in portions of this country it was found so difficult at first to induce stock to eat the vines, either when cured or made into ensilage, that even at a certain State experiment station the opinion was expressed that cowpeas were of no local value as feed for live stock. Subsequent developments proved that this crop has great possibilities even in the sections where the preliminary trials showed it to be very unpromising as a feed owing to the difficulty experienced in making stock eat the forage.

Much greater difficulty is usually experienced in inducing the stock to become accustomed to sweet clover than is the case with other legumes, but the fact that in at least half of the States in the Union stock have become accustomed to eat this plant indicates that the natural distaste which stock at first show can be successfully overcome.

Much effort is being given in several parts of the country to the development of a cumarin-free variety of sweet clover by selection and also by hybridizing it with smaller, less valuable species of sweet clover which do not have this bitter principle. Efforts are also being made looking to the introduction of less bitter strains from foreign countries. These efforts may in time prove successful, but at present they are not so important as it is sometimes thought, since stock can be readily induced to eat the ordinary sweet clover, and once they acquire the taste for it no difficulty is thereafter experienced in getting them to eat all that they require. It is also held that the cumarin or bitter principle reduces the danger of bloating. Cumarin is well known to physicians and druggists and for thousands of years has been used as a corrective, tonic, and antiseptic in intestinal disorders. The sweet clover starts its growth about two weeks in advance of the other ordinary pasture crops and at this stage is not especially bitter. When the cattle are turned on it at this time they are hungry for any green feed and eat it from the first, practically without exception. Close pasturing or an occasional clipping with a mower will insure the continued presence of the fresh shoots, which will thus be available throughout the season. The hay when properly cured is seldom refused by stock, but if they should refuse it a sprinkling of brine on the hay when the animals are salt hungry is usually all that is necessary to induce them to eat it. The rank flavor of sweet clover has been held by some to taint the milk when eaten by milk cows, but this is disputed by those who have utilized it on an extensive scale. Whether or not there is some narcotic principle in the cumarin, it is a well-known fact that once stock are induced to eat sweet clover for a few days they become quite fond of it and will often leave other grasses and clovers to eat it. Its palatability, and probably also its digestibility, decreases with the age of the plant and for this reason it should be utilized at as early a stage as is practicable.

COMPOSITION OF SWEET CLOVER.

In common with other legumes, sweet clover contains a relatively high percentage of protein, thus making it a source of this valuable constituent of farm feeds. Tables II and III, taken in part from Henry's "Feeds and Feeding," show the relative composition of several different kinds of feed.

TABLE II.—*Average percentage composition of sweet clover and other forage feeds and value of same per ton.*

Kind of forage.	Number of analyses.	Water.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract (fat).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Fresh sweet clover	7	77.0	1.8	3.9	6.9	9.4	0.6
Fresh alfalfa	23	71.8	2.7	4.8	7.4	12.3	1.0
Fresh red clover	43	70.8	2.1	4.4	8.1	13.5	1.1
Sweet-clover hay	6	7.7	7.5	13.3	26.9	42.6	2.1
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7	2.2
Red-clover hay	38	15.3	6.2	12.3	24.8	38.1	3.3
Timothy hay	68	13.2	4.4	5.9	29.0	45.0	2.5
Cowpea hay	8	10.7	7.5	16.6	20.1	42.2	2.2

TABLE III.—*Digestible nutrients in sweet clover and other forage crops and feeds and value of same per ton.*

Kind of forage or feed.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.			Value per ton of feed.
		Protein.	Carbohydrates.	Ether extract.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	
Sweet-clover hay	92.4	9.9	38.1	1.2	$18.49
Alfalfa hay	91.6	11.0	39.6	1.2	20.16
Red-clover hay	84.7	6.8	35.8	1.7	14.12
Timothy hay	86.8	2.6	43.4	1.4	9.80
Cowpea hay	89.3	10.8	38.6	1.1	19.76
Wheat bran	88.1	12.2	39.2	2.7	22.80
Shelled corn	89.1	7.9	66.7	4.3	20.16

The values per pound assigned as the basis of calculation of the value of the digestible nutrients in a ton of the feed as given in Table III are protein, $0.0674; carbohydrates (starches, etc.), $0.0064; ether extract (fats), $0.0112. These figures are merely relative, as the prices of the food elements vary in different sections of the country and from year to year. It will be noted that the value of sweet-clover hay on the above basis would be almost double that of timothy and intermediate between red clover and alfalfa, and that the actual market prices of the different feeds bear little relation to their theoretical value.

FEEDING EXPERIMENTS WITH SWEET CLOVER.

A great many farmers have reported successful experiments in feeding sweet clover to live stock, but relatively few of the experiment stations have performed definite feeding experiments to determine the exact value of sweet-clover hay as compared with other crops. The Wyoming Experiment Station, however, performed an interesting experiment with lambs. A number of pens of from 10 to 40 lambs each were each fed different mixtures of feeds for a period of two weeks. Those receiving sweet-clover hay, corn, and a small amount of oil meal made an average gain of 30.7 pounds per head as compared with 20.3 pounds for those receiving native grass hay, oats, and oil meal. Those receiving alfalfa and corn made a gain of 34.4 pounds per head. The details of the experiment with four of the pens of lambs are given in Table IV.

TABLE IV.—*Showing results of feeding tests with lambs.*

Ration.	Number of lambs.	Average gain per head in pounds for 14 days.	Pounds of feed required for 100 pounds of gain.					
			Sweet-clover hay.	Native hay.	Alfalfa hay	Corn.	Oats.	Oil meal old process.
Sweet-clover hay, corn, oil meal	10	30.7	637.5			293.2		[illegible]
Native grass hay, oats, oil meal	40	29.3		[illegible]			[illegible]	25.6
Alfalfa hay, corn	10	34.4			[illegible]	[illegible]		
Do	40	34.3			557.3	[illegible]		

The sweet-clover hay used in this experiment was stated to be stemmy in its nature and more than a year old. It is of interest to know that in spite of its stemminess the hay was eaten up close by the lambs.

At the Iowa Agricultural College a grazing experiment with young shoats was made comparing sweet clover and red clover. The details of this experiment are shown in Table V.

TABLE V.—*Comparative results of pasturing pigs on sweet clover and on red clover.*

Kind of pasture.	Number of pigs per acre of pasture.	Daily gain per head.	Gain for entire lot per acre.	Grain required for 100 pounds of gain (in addition to pasturage).
		Pounds.	*Pounds.*	*Pounds.*
Sweet clover	18	1.02	[illegible]	338
Red clover	15	1.13	2.304	333

The results of these technical experiments are thoroughly substantiated by numerous private feeding tests in various sections of the country. Hundreds of fat cattle which have been fed almost exclusively on sweet-clover hay as a roughage in central Utah are marketed annually. From certain sections of western Iowa steers have been turned off fat from sweet-clover pasture and have brought $1 per hundredweight premium over the ordinary grass-pastured stock marketed at Chicago from the same locality.

In a feeding experiment with sheep conducted by two students at the Iowa Agricultural College it was found that the protein digested in sweet clover fed alone was 69 per cent, and that the addition of corn to the hay ration increased the digestibility of sweet clover to 82 per cent. (See Table VI.) Alfalfa and red clover showed similar increases in the digestibility of their protein content when corn was added to the ration. The percentage of digestibility figured for the protein in the corn was the average of a number of digestion experiments. The probability is that the digestibility of the corn was also increased by the presence of the hay in the ration, so that not all the increase in the digestibility should be credited to the hay constituents of the different rations.

TABLE VI.—*Comparative percentage digestible of protein and of dry matter in sweet clover, in alfalfa, and in red clover.*

Ration.	Percentage digestible.	
	Protein.	Dry matter.
Sweet clover:		
When fed alone	69	52
When fed with corn	82	74
Alfalfa:		
When fed alone	70	61
When fed with corn	83	75
Red clover:		
When fed alone	46	49
When fed with corn	61	61

SWEET CLOVER AS A SOIL IMPROVER.

One of the most valuable qualities of sweet clover is its ability to improve the soil on which it grows. This it does in part by reason of its large roots, which break up the lower layers of the soil and by their rapid decay add a great deal of humus to the layers which lie below the usual depths of plowing (fig. 4). In addition to this the stubble and stems when plowed under add a good deal of humus to the soil. Its most important characteristic is the ability, which it enjoys in common with other legumes, of fixing nitrogen by means of the nitrogen-gathering bacteria which live in the tubercles on the roots of the plant. This ability enables it to add much nitrogen, a most costly fertilizer, to the soil in which it grows. Many legumes require considerable humus in the soil for anything like a good growth, but sweet clover seems to be a notable exception to this rule and will generally thrive where this usually essential factor is absent. The ability to thrive in such locations makes it especially valuable as a pioneer crop on poor, run-down, badly washed fields such as exist in parts of the Southern States, especially in limestone sections. Its ability to succeed on similar fields outside the limestone section has not yet been fully determined. As an instance of its effect on land it may be mentioned that in Alabama on poor, run-down soil it produced 6,672 pounds of hay per acre the first year and 7,048 pounds the second year, after which the stubble was plowed under and planted to corn. The corn produced 22.7 bushels per acre as compared with 16.2 bushels per acre upon an adjoining plat where sweet clover had not been grown. The year following a similar experiment in the same section showed the corn to have yielded 28.2 bushels on the sweet-clover stubble land as compared with 21.2 bushels where cotton instead of the sweet clover preceded the corn. A total of 11,376 pounds of hay had been cut from the sweet-clover plats during its two seasons of growth.

At the Ohio Experiment Station sweet-clover land gave a yield of 26.9 bushels of corn, as compared with 18.6 bushels on similar land not in sweet clover the previous year. An experiment performed at Tost, Germany, showed that sweet clover preceding oats increased the yield of oats 17 bushels per acre. Part of the field was devoted to potatoes, with the result that the yield was more than doubled when compared with an adjoining plat not previously seeded to sweet clover. Some idea as to the large amount of green material which sweet clover provides for soil improvement is shown by a report from the Ontario Experiment Station in the cutting of over 30 tons of green fodder per acre, as compared with 13½ tons for mammoth clover, which stood next in rank.

Sweet clover has given excellent results in improving the texture of sandy lands and gumbo soils which are too stiff to otherwise produce satisfactory crops. Its effect on gumbo and adobe soils is in part an aid to drainage in that its large succulent roots do much toward loosening up the texture of the hardpan subsoil. In the West it has shown itself able to grow on soil so strongly impregnated with alkali that little else than the salt-grass among the native plants can exist. After a crop of sweet clover has been grown on such soil it is usually possible to grow some other field crop.

SWEET CLOVER IN ROTATIONS.

Being a biennial, sweet clover lends itself readily to short rotations. In this respect it is similar to red clover. Its demand for a very firm seed bed makes it less easy to obtain a stand on cultivated fields than is usually the case with the red clover.

When used in the semiarid regions in rotations with small grain it has failed to give as good results as rye or some other crop used for green manure, on account of its effect on the soil moisture. It is usually not ready for plowing under as early in the season as rye and thus a shorter time for the moisture-conserving fallow is allowed.[1] This disadvantage might be obviated to some extent by following the sweet clover with corn, which does not require so much soil moisture early in the season. In the East where these conditions of light rainfall do not exist it is not so essential that a corn crop follow the sweet clover.

---

[1] See Bulletin 187, Bureau of Plant Industry, entitled "A Study of Cultivation Methods and Crop Rotations for the Great Plains Area," by E. C. Chilcott.

ERADICATION OF SWEET CLOVER.

The fear is often expressed that sweet clover will escape and prove a troublesome weed if it is seeded on the farm in one of the regular rotations. In answering this objection it may be stated that in the sections where sweet clover has been most utilized it is almost universally held that no difficulty is experienced in ridding a field of sweet clover when it is desired to follow it with some other crop. In the South one year in corn or cotton will usually remove all but an occasional trace of the sweet-clover plants. Being a biennial it is only necessary to prevent its seeding for two years and the stand is destroyed with the possible exception of plants from some "hard" seed which failed to germinate the first or second season and which may come up occasionally in later seasons. The fact that it makes no seed the first season and seeds only the second season insures its being destroyed in cornfields and other clean cultivated fields before it has an opportunity to produce seed. In grain fields it need not be feared, since the plowing necessary for the grain crop will turn under before they have seeded any plants which have started. It perseveres as a weed only in those places which are not completely cultivated at intervals of two years or less. Even in these places it is not wholly undesirable, since some vegetation is almost sure to occupy such places and other vegetation would presumably furnish less sustenance for bees, nor is other vegetation apt to be so efficient in building up such waste places and increasing their fertility.

Its control becomes especially difficult only in irrigated localities where the old plants along the ditch banks furnish a crop of seed which is scattered over the land by the irrigating water each year. The only way to prevent such an occurrence is to keep the plants cut off along the ditches.

SEED PRODUCTION OF SWEET CLOVER.

In most parts of this country the seed production of sweet clover is still in a rather primitive state. It is the common practice in the South to cut the plants when damp, place them in convenient piles, and later flail off the hulls on canvas with sticks or beaters. The seed so obtained is generally sold in the hulls, although they may be readily removed by the use of a clover huller. The unthrashed hay is rather too coarse to run easily through a huller, but the difficulty can be avoided by thrashing the seed first and then hulling it. Imported seed is generally hulled, while native-grown seed is apt to be sold in the hull just as it comes from the flail or thrashing machine, but with the trash and leaves mostly removed. The seed shatters very easily, and great care must be taken to avoid losing a large proportion of it while harvesting. The largest yields of seed come from stands not too thick and which have not first been cut for hay, although satisfactory seed crops have usually been obtained from fields which have produced one crop of hay in the North and two in the South when the rainfall is sufficient (figs. 10 and 15). Care should be taken to cut the stubble of the preceding hay crops rather high, so there may be ample room for new shoots, as the plants do not readily form new crown shoots, as alfalfa does. When flailed out the straw may be returned to the field to be plowed under for fertilizer. It should preferably be applied to any gulleys which may be in the field and thus stop the washing. The straw is also used as a winter feed for cattle.

ENEMIES OF SWEET CLOVER.

Sweet clover appears to be remarkably free from enemies of all kinds, including insect pests, parasitic plant diseases, burrowing rodents, or other similar animals. It is possible when it becomes more generally utilized as a field crop that injurious enemies will be recognized, but at present there appears to be no immediate danger from any that have been reported. A few parasitic plant diseases occasionally occur on the growing plants, but they are not usually troublesome. Among insects an aphis (*Aphis medicaginis* Koch) has at times proved injurious to the sweet-clover plants.

SWEET-CLOVER PRODUCTION IN DIFFERENT SECTIONS OF THE UNITED STATES.

In a number of different sections of the United States the early opposition to sweet clover has been overcome, and this plant is now well established as a regular farm crop and recognized as a valuable addition to the list of available crops for forage purposes, for green manure, and for soil improvement. The methods of handling this crop vary to some extent in these different sections.

SWEET CLOVER IN MISSISSIPPI AND ALABAMA.

Sweet clover appears to be especially well adapted to the black prairie soils of northwestern Mississippi and central and western Alabama. In this section it is found chiefly on the limestone hills and knolls where the soil is thin and poor in humus. On these soils it is utilized as pasturage or as hay for two or more years, after which the ground is usually in condition for the raising of profitable crops of corn or cotton. Before the extension of alfalfa on the lower lying fields in the black prairie section the use of sweet clover was common on such soils, but with the introduction of alfalfa culture on these better soils sweet clover has been sown more on the hilly lands. In addition to furnishing pasture and green manure it is also efficient in arresting the washing on hilly fields. It may be cut for hay once or twice the first season and three times the second season. It is also valuable for renovating canebrake fields and is the earliest pasture available. When seeded on thin soil of limestone origin it succeeds as perhaps no other crop will, and in three years deepens the soil to such an extent that other crops may be profitably produced. It is seeded very early in the spring either alone or with oats as a nurse crop. So far as known it has not spread to any considerable extent on the clay soils immediately adjoining the limestone lands, although it now grows naturally on much of the limestone lands. The division line between the two soil types is exceedingly sharp in many places in this section, and the absence of the sweet clover from the clay soils when it is so abundant a few feet away has been the occasion of considerable comment. It is utilized as a feed for horses, mules, and cattle both as pasturage and as hay.

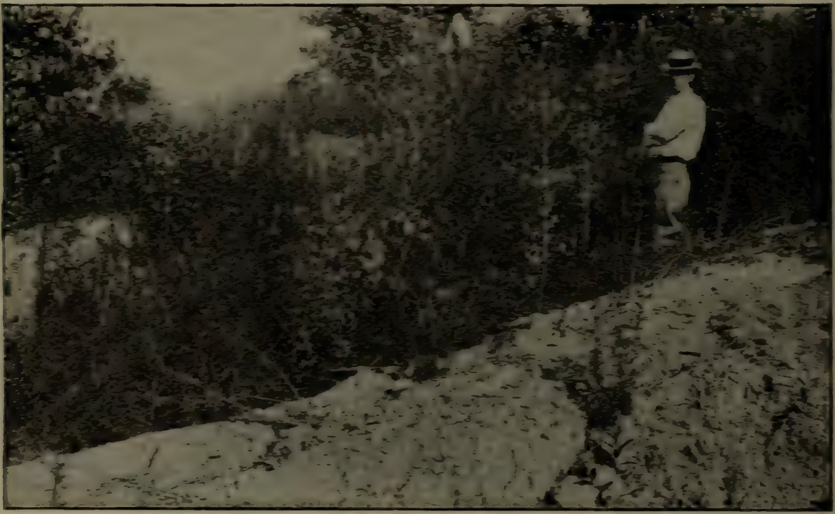


FIG. 12.—Sweet clover arresting erosion in a gullied field in Kentucky. The 1-year-old plants reach the knees of the figure in the foreground.

SWEET CLOVER IN KENTUCKY.

On the limestone hills of northern Kentucky sweet clover is proving to be a very valuable plant in restoring the old-time productivity of the soils. A decade ago many farms were coming to be abandoned, owing to their low productive capacity. Many of the fields contained gullies which washed, making the farms even less valuable. Sweet clover was introduced as a bee plant in some of the waste places in this section and proved so efficient as a soil improver that it has been largely utilized on a great many farms in this section.

Figure 12 indicates the method by which it stopped the gullies, which were rapidly ruining the field. Figure 13 illustrates a cornfield on the ordinary soil of this section, while figure 14 represents a cornfield on land which a few years before was too poor to grow anything but sweet clover. As a result of the introduction of sweet clover many of these farms are no longer abandoned but are producing satisfactory incomes for those who are working them. The fields are utilized as pastures and for hay while the soil is being built up and the gullies stopped from washing (fig. 12). When the process of natural reclamation has gone far enough the ground is plowed and put into corn.

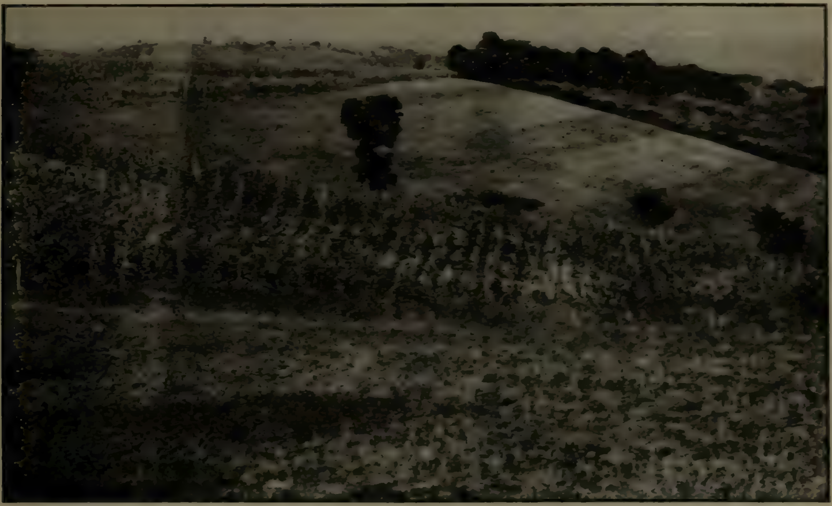


FIG. 13.—Scene on a nearly worn-out farm in northern Kentucky. Corn almost a total failure.

SWEET CLOVER IN UTAH.

Sweet clover has been grown for a number of years in Utah in the irrigated sections surrounding Ferron in the central part of the State. This locality is noted for the production of alfalfa seed, and a large percentage of the agricultural land of that community is devoted to this crop. The soil for the most part is rather poor in the beginning, and it has been found that sweet clover will put the soil in condition for alfalfa sooner than any other treatment available. At the same time it furnishes forage for cattle and horses which is practically equal in feeding value to the alfalfa. Most of the farmers around Ferron have had more or less experience with the growing of sweet clover and a large number are enthusiastic advocates of it as a means of increasing the value of their land and putting it in condition to seed to alfalfa. The soil is derived largely from the disintegration of slaty shale and seems to be well adapted to the production of sweet clover. No artificial inoculation is needed. and under irrigation it yields as much as 5 tons of hay per acre. The general practice is to seed the sweet clover with a grain crop in the spring; then after harvesting the grain crop the sweet clover can be pastured during the remainder of the summer and autumn. The following season two full crops of hay may be cut. It is usually plowed up the second season and followed with a crop of oats or wheat. The dairy farmers around Ferron are practically unanimous in the opinion that sweet-clover hay will produce as much or more milk than alfalfa, and it is also very highly prized for feeding horses during the winter. The principal objection to its more extended use is the difficulty which is encountered in curing the hay. The general practice is to bunch it while yet quite green and allow it to cure in the shock (fig. 15). This requires that it remain shocked for at least one week, and then care must be used in hauling and stacking to avoid shattering the leaves.

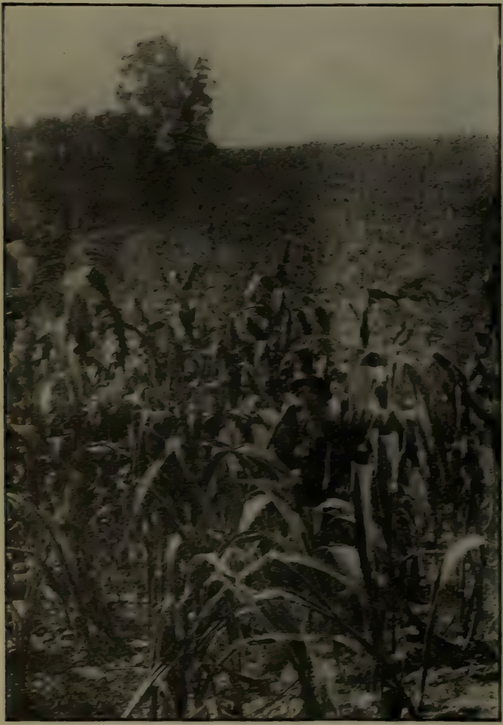


FIG. 14.—View of a cornfield where sweet clover was previously grown. This field is about one mile from the scene shown in figure 13.

The farmers in most of the other irrigated districts of Utah do not seem to have appreciated the value of sweet clover, and in many localities it is considered a pest, growing vigorously along the irrigation ditches and scattering from these vantage points over the remainder of the field, being carried by the irrigation water.

SWEET CLOVER IN COLORADO AND WYOMING.

Extensive areas in the irrigated districts of Colorado and Wyoming have become seeded to sweet clover, but as yet it is regarded largely as a weed and little use seems to be made of it either as hay or as pasture. It is found mostly in localities where seepage has made the land useless for other crops. In such places it grows vigorously and occupies the ground to the exclusion of other less valuable plants. The farmers are anxious to make use of it as a crop, but as yet few have investigated the subject sufficiently to understand its importance as a crop available for use on those parts of their farms which would otherwise be unproductive.

The Wyoming Agricultural Experiment Station has conducted feeding experiments with sheep which have demonstrated fully its value for this class of live stock; still, very few sheep owners are seeding sweet clover on their waste lands or making any consistent effort to increase its acreage throughout the State.

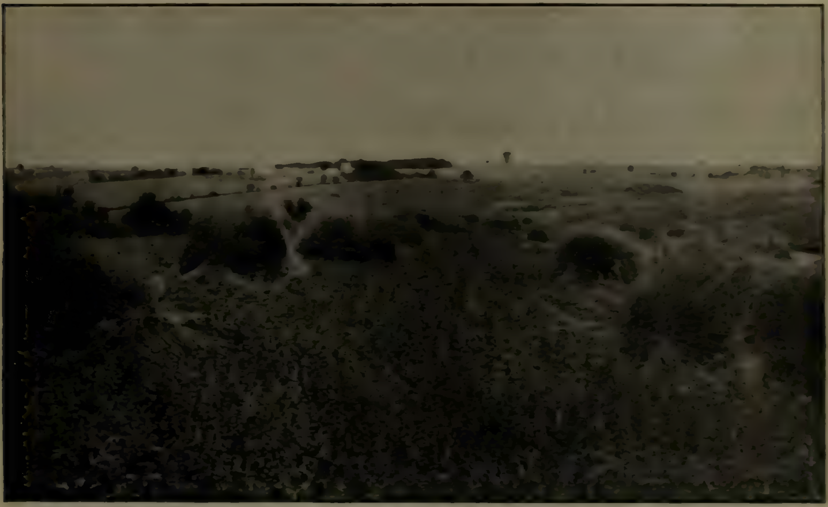


FIG. 15.—Sweet clover in shocks ready for the seed huller.

SWEET CLOVER IN NEBRASKA.

Scattered fields of sweet clover are to be found throughout Nebraska, but no continuous and consistent use of it has occurred in any part of the State. In the eastern part of the sandhill district a number of settlers have seeded it on their sandy soil and have been very well pleased with the results obtained in improvement of their pasture land and in the hay obtained therefrom (fig. 16). When seeded in the "blowouts" which often occur in the sandhill district it has held on tenaciously, reseeding itself at the end of its growing period. Its greatest value to this locality probably arises from the improvement of the soil, but a number of the settlers have found it much better than the native hay for feeding stock. Its growing popularity is evidenced by a recent statement of the manager of a large ranch in the eastern part of the sandhill district of Nebraska, that the ranch owners were expecting to seed on their ranches an area requiring a ton of sweet-clover seed.

SWEET CLOVER IN THE NORTH-CENTRAL STATES (IOWA, WISCONSIN, ILLINOIS, INDIANA, OHIO, AND MICHIGAN).

In the North-Central States the somewhat isolated places where sweet clover has been grown are sufficiently numerous to indicate that it is widely adapted and could be much more widely utilized than it is at present. Its successes are sufficiently numerous to indicate that they are not due to any particular soil or climatic conditions. In these sections one crop of hay the first season and a crop of hay and also a crop of seed the second season are possibilities. Spring seeding is generally recommended, and this may either be alone or with grain as a nurse crop. Throughout this section sweet clover must compete with red clover, alsike clover, and alfalfa. It is not yet to be recommended where these crops grow successfully, for the present at least, so it is best to utilize it under conditions where these more valuable forage plants can not be successfully produced.

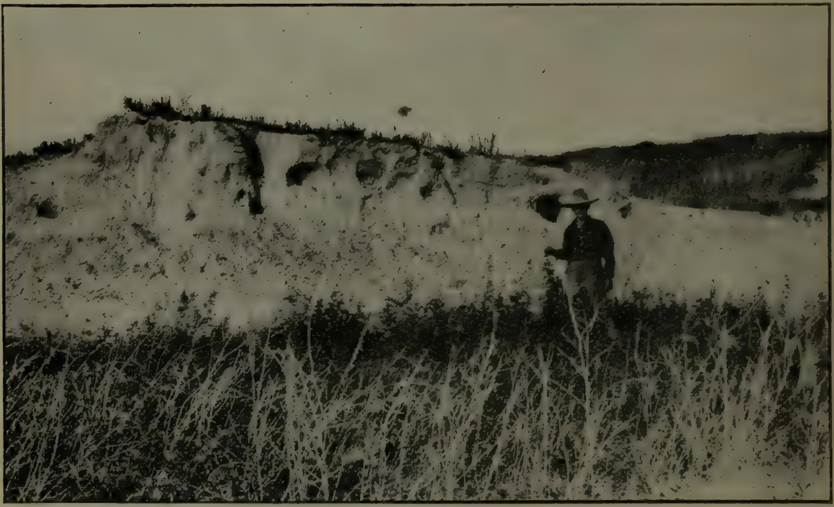


FIG. 16.—Sweet clover growing in practically pure sand in western Nebraska.

SUMMARY AND CONCLUSIONS.

The data at hand indicate that when properly handled sweet clover is a valuable addition to the farm crops of many sections.

It is efficient as a soil renovator, by reason of the large amount of nitrogen it is able to take from the air as well as the humus added to the soil when it is turned under or from the decay of roots when the crop is harvested.

Sweet clover will grow on soils too low in humus content for the favorable growth of most other legumes.

Its large roots, which develop the first year, facilitate drainage and do much to break up and improve the tilth of the soils which lie below the reach of the plow, as these roots rapidly decay when the plant dies, and their effect is therefore almost immediate.

Sweet clover occurs as a weed usually along roadsides, in vacant lots, in fence corners, along irrigation ditches, and in other places not utilized or cultivated.

It is not troublesome in cultivated fields or meadows as ordinarily treated, because it can not persevere more than two years from one seeding.

The presence of some hard seed which does not usually germinate the first season may enable it to continue in a meadow for a number of years longer.

Sweet clover can usually be killed by mowing when in full or late bloom.

It is regarded as a pest in irrigated fields of the West, where the irrigating water carries in the seed from scattered plants which quite commonly grow along the ditch banks.

In irrigated sections where alfalfa succeeds well, the introduction of sweet clover is not to be recommended.

The presence of sweet clover on otherwise bare soils, even as a weed, is not necessarily to be condemned, as it is building up the soil in both humus and nitrogen content and is thus preparing it for subsequent profitable crops.

The great numbers of failures in obtaining a stand of sweet clover are due in part to the high percentage of hard seed and in part to seeding on too loose a seed bed, especially when combined with a lack of inoculation.

Spring seedings in general are satisfactory, but in the South excellent stands are also obtained from late winter seedings. The latter method may prove generally applicable wherever there is abundant rainfall.

Analyses and feeding experiments indicate that it is nearly equal to alfalfa in feeding value.

The feeding value, palatability, and presumably the digestibility decrease rapidly after the blooming period.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Membr of Congress or the Secretary of Agriculture.]

○

1490 Issued March 13, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 486.

Experiment Station Work,
LXVIII.

Compiled from the Publications of the Agricultural Experiment Stations.

THE FEEDING OF A GRAND CHAMPION STEER.

THE UTILIZATION OF DAIRY BY-PRODUCTS AS FOOD.

JANUARY, 1912.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

THE AGRICULTURAL EXPERIMENT STATIONS.

ALABAMA—
College Station: *Auburn;* J. F. Duggar.[1]
Canebrake Station: *Uniontown;* L. H. Moore.[1]
Tuskegee Station: *Tuskegee Institute;* G. W. Carver.[1]

ALASKA—*Sitka:* C. C. Georgeson.[2]
ARIZONA—*Tucson:* R. H. Forbes.[1]
ARKANSAS—*Fayetteville:* C. F. Adams.[1]
CALIFORNIA—*Berkeley:* E. J. Wickson.[1]
COLORADO—*Fort Collins:* C. P. Gillette.[1]

CONNECTICUT—
State Station: *New Haven;* E. H. Jenkins.[1]
Storrs Station: *Storrs;* L. A. Clinton.[1]

DELAWARE—*Newark:* H. Hayward.[1]
FLORIDA—*Gainesville:* P. H. Rolfs.[1]
GEORGIA—*Experiment:* Martin V. Calvin.[1]
GUAM—*Island of Guam:* J B. Thompson.[2]

HAWAII—
Federal Station: *Honolulu;* E. V. Wilcox.[2]
Sugar Planters' Station: *Honolulu;* C. F. Eckart.[1]

IDAHO—*Moscow:* W. L. Carlyle.[1]
ILLINOIS—*Urbana:* E. Davenport.[1]
INDIANA—*La Fayette:* A. Goss.[1]

IOWA—*Ames:* C. F. Curtiss.[1]
KANSAS—*Manhattan:* E. H. Webster.[1]

KENTUCKY—*Lexington:* M. A. Scovell.[1]

LOUISIANA—
State Station: *Baton Rouge;*
Sugar Station: *Audubon Park, New Orleans;*
North La. Station: *Calhoun;*
Rice Station: *Crowley;*
W. R. Dodson.[1]

MAINE—*Orono:* C. D. Woods.[1]
MARYLAND—*College Park:* H. J. Patterson.[1]
MASSACHUSETTS—*Amherst:* W. P. Brooks.[1]
MICHIGAN—*East Lansing:* R. S. Shaw.[1]
MINNESOTA—*University Farm, St. Paul:* A. F. Woods.[1]
MISSISSIPPI—*Ariculturaal College:* E. R. Lloyd.[1]

MISSOURI—
College Station: *Columbia;* F. B. Mumford.[1]
Fruit Station: *Mountain Grove;* Paul Evans.[1]

MONTANA—*Bozeman:* F. B. Linfield.[1]
NEBRASKA—*Lincoln:* E. A. Burnett.[1]
NEVADA—*Reno:* J. E. Stubbs.[1]
NEW HAMPSHIRE—*Durham:* J. C. Kendall.[1]
NEW JERSEY—*New Brunswick:* J. G. Lipman.[1]
NEW MEXICO—*Agricultural College:* Luther Foster.[1]

NEW YORK—
State Station: *Geneva;* W. H. Jordan.[1]
Cornell Station: *Ithaca;* L. H. Bailey.[1]

NORTH CAROLINA—
College Station: *West Raleigh;* C. B. Williams.[1]
State Station: *Raleigh;* B. W. Kilgore.[1]

NORTH DAKOTA—*Agricultural College:* J. H. Worst.[1]
OHIO—*Wooster:* C. E. Thorne.[1]
OKLAHOMA—*Stillwater:* J. A. Wilson.[1]
OREGON—*Corvallis:* J. Withycombe.[1]

PENNSYLVANIA—
State College: T. F. Hunt.[1]
State College: Institute of Animal Nutrition, H. P. Armsby.[1]

PORTO RICO—
Federal Station: *Mayaguez;* D. W. May.[2]
Sugar Planters' Station: *Rio Pedras;* J. T. Crawley.[1]

RHODE ISLAND—*Kingston:* H. J. Wheeler.[1]
SOUTH CAROLINA—*Clemson College:* J. N. Harper.[1]
SOUTH DAKOTA—*Brookings:* J. W. Wilson.[1]
TENNESSEE—*Knoxville:* H. A. Morgan.[1]
TEXAS—*College Station:* B. Youngblood.[1]
UTAH—*Logan:* E. D. Ball.[1]
VERMONT—*Burlington:* J. L. Hills.[1]

VIRGINIA—
Blacksburg: S. W. Fletcher.[1]
Norfolk: Truck Station, T. C. Johnson.[1]

WASHINGTON—*Pullman:* R. W. Thatcher.[1]
WEST VIRGINIA—*Morgantown:* E. D. Sanderson.[1]
WISCONSIN—*Madison:* H. L. Russell.[1]
WYOMING—*Laramie:* H. G. Knight.[1]

---

[1] Director.

[2] Special agent in charge.

EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

CONTENTS OF NO. LXVIII.

Page.

The feeding of a grand champion steer 5
    Shamrock, 1902 5
    Challenger, 1903 5
    Clear Lake Jute 2d, 1904 6
    Black Rock, 1905 6
    Fyvie Knight, 1908 7
    King Ellsworth, 1909 7
    Shamrock 2d, 1910 8
    Victor, 1911 8
    Scotch method of feeding animals for exhibition 9
The utilization of dairy by-products as food 12
    Utilization of buttermilk 13
        Buttermilk as a beverage 13
        Buttermilk cheese 14
        Part buttermilk cheese 18
            Hand cheese 18
            Leather cheese 19
            Danish export cheese 19
            Manur cheese 19
            Pultost cheese 19
            Sap Sago cheese 20

The utilization of dairy by-products as food—Continued.

Page.
Utilization of buttermilk—Continued.
Buttermilk cream 20
Condensed buttermilk 20
Buttermilk sherbet 21
Utilization of whey 21
Whey butter 21
Albumin or whey cheeses 23
Ziger 23
Mysost 24

ILLUSTRATIONS.

Page.
Fig. 1. Three stages of the draining process 16
2. A draining rack suitable for a large creamery 17

EXPERIMENT STATION WORK.[1]

THE FEEDING OF A GRAND CHAMPION STEER.

Steers fitted and exhibited by agricultural colleges and experiment stations have won the grand championship at the International Live Stock Exposition at Chicago eight times during the past 12 years. More or less complete records have been kept of the methods of feeding these steers, and it is believed that the following compilation from these records and from accounts of Scotch methods of feeding cattle for exhibition will furnish some lessons of practical interest and value.

SHAMROCK, 1902.

The champion steer in 1902 was Shamrock, a grade Angus, bought by the Iowa Agricultural College when a calf, winning the championship as a 2-year-old. During the growing period he was not pushed rapidly, as a tendency to coarse bone indicated that he might become too rough. His feed consisted of roots and clover hay for roughage, cooked bran and ground oats, moistened oil cake and corn-and-cob meal. The last few months of the finishing period he was given all he could eat. Molasses water was used as an appetizer on the corn-and-cob meal and cooked mixture. At the time of the show Shamrock weighed 1,805 pounds and sold for 56 cents per pound.

CHALLENGER, 1903.

Challenger, the grand champion steer at the International of 1903, was a grade Hereford, purchased by the University of Nebraska in April for 5 cents per pound and shipped to Lincoln. He was put on a ration consisting of corn 50 per cent, oats 25 per cent, wheat bran 15 per cent, and linseed meal 10 per cent. He was also fed liberally on alfalfa hay and a small quantity of prairie hay. During the summer he was allowed the run of the grass pasture a few hours each day, but was given all of the grain mixture he would consume in connection with the pasture. In November he was given a few sliced beets. During the six months he made a gain approximately of 100 pounds per month and weighed about 1,750 pounds.

---

[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

CLEAR LAKE JUTE 2d, 1904.

The grand champion steer at the International for 1904 was Clear Lake Jute 2d, a 2-year-old Angus, which was fitted for the show at the Minnesota Experiment Station. The methods of feeding and the weights of this steer from December 1, 1903, to October 11, 1904, are given in the following table:

Feed and weight records of champion Aberdeen-Angus bullock, Clear Lake Jute 2d, by periods.

	Dec. 1, 1903, to Jan. 4, 1904 (5 weeks).	1904			
		Jan. 4 to Mar. 28 (12 weeks).	Mar. 28 to June 28 (13 weeks, 1 day).	June 28 to Sept. 27 (13 weeks).	Sept. 27 to Oct. 11 (2 weeks).
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Corn	62.47	92.40	72.30	108.50	78.40
Bran	208.25	320.60	242.40	235.10	39.20
Oats	124.95	157.00	111.30	220.85	68.61
Peas	....	....	....	35.00	....
Oil cake	20.82	30.80	27.60	33.95	9.79
Barley	....	25.20	110.40	....	....
Hay	343.00	665.00	826.00	714.00	168.00
Pasture	....	....	(1)	(2)	....
Roots	483.00	994.00	728.00	189.00	168.00
Corn fodder	....	266.00	....	....	....
Live weights (initial)	1,620.00	1,620.00	1,685.00	1,710.00	1,790.00

[1] 5 weeks.

[2] 10 weeks.

BLACK ROCK, 1905.

Black Rock, the champion in 1905, was a 2-year-old grade Angus purchased by the Iowa Experiment Station as a yearling. During the first month after his purchase he was kept in an open shed and fed ear corn cut into pieces about 2 inches long and mixed with a little bran. He was then turned into a pasture with other steers and fed soaked corn with some oats, bran, and cut hay. As the steers were not gaining fast enough at the end of three weeks the corn was cooked and barley and oats added to the ration. Corn fodder was given for roughage. Grain was given twice a day until June, when the steers were annoyed so much by flies that they were kept in a barn and fed three times a day with hay and pastured at night. At this time the grain mixture consisted of corn, oats, bran, flaxseed meal, and cottonseed meal. Black Rock received about 8 pounds of this feed at a time. The grain was cooked at night. This was continued until the middle of August. From that time until he was taken to the show he was fed four times a day, at 5 in the morning, 12 m., 5.30, and 9 p. m. He was kept out nights until October 1. After that he was kept in the barn the entire twenty-four hours except for a short walk for exercise before feeding in the morning. At slaughter Black Rock weighed 1,610 pounds, and dressed 69.97 per cent live weight.

FYVIE KNIGHT, 1908.

The feeding of Fyvie Knight, the grand champion steer of the International in 1908, exhibited by the Indiana Experiment Station, was described in the Chicago Farmers' and Drovers' Journal of December 2, 1908, as follows:

> The steer came to the farm a thin bull calf, where he was castrated and turned in with other steers kept on the farm for instructional purposes. He has been on full feed about 10 months, and during the past summer ran on blue-grass pasture at night and during the early part of the day. As cooler weather came on he was turned on grass during the day and kept in at night. He has received a ration of bran, shelled corn, cracked corn, ground oats, wheat, silage, and clover hay. The ration used just before entering the show was bran one part, cracked corn three parts, shelled corn four parts (fed at noon), ground oats seven parts, cracked wheat one part, silage 1½ pounds per day, with light ration of clover hay. He had always been an excellent feeder, although somewhat nervous in the stall. Doubtless he reached his most perfect form during the show. This was his first year to show, and he had never been off feed and had never received an excessively heavy ration. His gain for the past six months was 300 pounds, for the month of November 50 pounds. * * * The steer was used by the agricultural students of [Purdue] university during the fall months to represent the best type of beef animal in the work of scoring and judging beef steers. He was kept on the farm primarily for instructional purposes, although he had been looked upon for the past year as a very promising show steer.

KING ELLSWORTH, 1909.

The Angus steer King Ellsworth, grand champion in 1909, was calved in Illinois September 6, 1906, and was finished at the Kansas station. Prof. R. J. Kinzer describes[1] his feeding and handling as follows:

> From the time he arrived at the college farm, immediately after the close of the International in 1908 [where he had been shown as a yearling], until he left his principal roughness was alfalfa hay, and his grain ration was corn meal, bran, and oil meal. During the winter of 1908–9 he ran in an open yard during the day with the other steers that were being fitted for show, and at night they were stabled in a fairly comfortable shed. During the winter they were given a little corn fodder to pick at during the day and were fed grain only twice a day and then only a limited quantity, which was about equal parts of corn meal and bran. From about the middle of March until the middle of June a cooked or steamed feed was fed once a day. This food was prepared by cooking the corn a couple of hours in a large kettle. The water was then drained off and the corn was piled on the floor, covered with bran and chaffed alfalfa leaves. The heat from the corn steamed the bran and alfalfa, and it was allowed to remain in this pile until cooled, then the bran and alfalfa were thoroughly mixed with the corn.
>
> During the early part of the season until the flies became bad the steers were turned on blue-grass pasture for a few hours each day, and during the fly season they were stabled during the day and allowed to run in a small blue-grass

---

[1] The Breeder's Gazette [Chicago], 56 (1909), p. 1370.

paddock at night. Plenty of exercise was given the steers during the entire year, they being required to walk 1 to 1½ miles per day.

There was neither sugar, molasses, nor drugs of any description used in the fitting of King Ellsworth. His official weight at the International of 1908 was 1,420 pounds. For fear of getting him too heavy he was never crowded to the limit. He was always a very hearty eater, always ready for his feed, and never during the entire year showed the slightest disposition toward being "mincy" about his eating or off feed, and was never at any time given all the feed that he would have consumed.

No accurate account was kept of just the amount of feed he consumed, but it probably would not be far from an average of 10 pounds of corn meal, 6 pounds of bran, and 1 pound of oil meal per day, with all the alfalfa he cared for. His official weight at St. Joseph in September was 1,660 pounds; at Kansas City, in October, 1,710, and at the International 1,750 pounds.

SHAMROCK 2d, 1910.

The method of feeding the grand champion steer of 1910, which was finished at the Iowa station, was as follows: The steer was dropped January 10, and in addition to a nurse cow the latter part of April was fed good clover hay and a grain ration of corn, wheat bran, and oil meal in the proportions of 3:2:1. September 1 he was given an additional nurse cow, although both foster mothers were weakening in milk. Roots and green cornstalks and ears were then added to the ration and the grain allowance was cut down somewhat. Boiled wheat and oats was given in place of the dry feed. The animal was then eating from 9 to 11 pounds of cooked feed, 25 pounds of roots, and 5 pounds of clover hay per day. In 205 days he gained 794 pounds, lacking only 26 pounds of being 4 pounds per day.

VICTOR, 1911.

Victor, the winner at the 1911 International, was a grade Angus, bred in Iowa. His sire, Keymura, was the junior champion Angus bull at the International when a 2-year-old. Victor was calved in January, 1909, and won the second prize as junior grade calf that year. The following March he was champion steer at the Fort Worth show, and Angus champion at the Iowa State Fair, and also first in his class at the American Royal Show at Kansas City.

He was bought by the Iowa Agricultural College October 15, 1910, weighing 1,100 pounds, a little light for his age. He was light in the quarters, a little down in the back, and beginning to get a little rough at the tail head. He showed such a tendency to "roll" over the loin that many judges pronounced him down at that time. He was put on a ration of boiled wheat and oats, mixed in equal parts, with a little grain, 2 or 3 pounds of roots, and plenty of clover hay. This was given three times a day and the amount limited only by the appetite of the steer. To keep up circulation and appetite he was given a 2-mile walk every day. By the time of the 1910 International he weighed 1,238 pounds, showed first in his class, and was reserve champion yearling. The problem then was to keep a steer of his ripeness in the smooth condition demanded by a champion animal. He was shipped back to Ames and roughed through the winter, and twice a day was given what he would eat up clean of equal parts of shelled corn and bran, with a little corn meal. Clover hay was supplied as roughage and 3 or 4 pounds of silage was added as an appetizer. During the day he was turned out in the field, and as soon as grass came he was put on pasture. About May 1 he weighed the same as at the International. On the approach of hot weather he was left in a cool dark basement stall during the day and turned on pasture at night. About September 1 his ration was increased to three meals a day, the morning and noon meals consisting of equal parts of corn, oats, and bran. The afternoon feed was a boiled mixture of 3 parts oats, 1 part wheat, and 1 part peas. The grain ration was increased as fast as he would clean it up, and in addition he was given about 3 pounds of roots. As soon as green corn was fit to feed he ate all he could clean up at one feed in the afternoon. Though he showed signs of getting patchy, the soft-boiled feeds kept him in a smooth condition.

Early in October the number of feeds was increased to four a day, two meals being boiled feed, and all that the steer would eat was fed at a time. This plan was kept up for one week before the show, when the boiled feed was taken out of the ration to guard against shrinkage in shipping and showing. At the time of the show Victor weighed 1,670 pounds, a gain of 450 pounds since May 1. This gain of 2 pounds a day was not phenomenal, but was a good average for a steer that was supposed to be finished a year previous. He sold for 90 cents a pound and dressed 69.87 per cent of live weight.

The important part which the judgment and skill of the feeder plays in the successful handling and feeding of exposition animals is brought out with especial emphasis in the case of this animal. These were doubtless no less important in the other cases.

SCOTCH METHOD OF FEEDING ANIMALS FOR EXHIBITION.

The Scottish method of feeding cattle for exhibition is described[1] by W. J. Kennedy, of the Iowa station, as follows:

> The Scottish cattle feeders are not only very successful feeders of cattle for market purposes, but they are also unsurpassed in the feeding and bringing out of superb fat cattle for show purposes. At the leading fat-stock shows in Great Britain the cattle from Scotland invariably win the highest honors. While investigating the other lines of live-stock feeding, the writer also secured

---

[1] The Breeder's Gazette [Chicago], 48 (1905), pp. 268, 269.

some information pertaining to the methods of feeding practiced by the most successful exhibitors of fat cattle. In this line of work the greatest amount of attention is given to the feeding of 2-year-old cattle, as at all the leading shows there are no classes for fat calves, and the feeders of yearlings do not aim to have them ripe at this age, but rather to have them in a nice sappy condition, so that they will go on well and come back as 2-year-olds in prime form. Thus the methods of feeding practiced are such as will have a tendency to produce good growth and uniform development during the first 12 months, a continuation of growth with a slight increase in flesh during the second 12 months, some growth and a fair amount of flesh during the next 6 months, and then an abundance of good firm flesh combined with a tendency to ripen during the next 5 months, so that the animal will have sufficient size and a wealth of smooth, mellow flesh at show time.

The calves are allowed to suckle their dams or nurse cows during the first 9 or 10 months and are fed, in addition, some sliced turnips or swedes and fine hay during the winter months and grass during the summer season, with some crushed oats, ground barley, and linseed cake. The amount of grain and cake fed is not large, as good growth combined with a fair amount of flesh, not fat, is sought for. From weaning time on they are fed on hay, turnips, and a grain mixture of linseed cake, crushed oats, wheat bran, and ground barley or corn meal. This ration is continued until grass season. The method of feeding then varies, as those animals which are to be shown as yearlings are fed heavier grain and cake rations than those which are not to be shown until 2 years old.

Yearlings intended for show purposes are also housed a great deal of the time, while the others are allowed to run in grass and are fed in addition some grain and cake. Those intended for show yearlings are fed more grain and cake, also mashes and steamed or cooked food. The amount fed is varied to suit the needs of the animal and is regulated by the eye of the feeder, as a rule, and not by set standards. During the fall months roots and hay are fed in conjunction with a grain and cake mixture composed of linseed cake, crushed oats, wheat bran, ground barley, corn meal, and perhaps a little pea meal or bean meal. These methods of feeding are continued until show time. A great deal of attention is given to the question of exercise, which is either furnished by allowing the animals a few hours each day in a paddock or grass lot or by being walked for a half an hour or more by an attendant.

It is the feeding of the 2-year-old animal that taxes the skill of the feeder. The majority of the feeders aim to have their animals make good growth and gradually gain in flesh until the month of May. From this time until the middle of August the rations are gradually increased and grass and other green food is fed to purify the blood and cool the system. From the middle of August until snow time the animals are forced to their utmost capacity. Those who commence heavy feeding at an earlier date experience difficulty, as their animals are likely to be overdone, while those who commence at a later period find it very difficult to have weight and flesh enough at show time. While the different feeders use somewhat different combinations of feeding stuffs in the feeding of their cattle, still the list from which the selections are made is not very wide.

During the fall, winter, and early spring months for roughage the various kinds of hay are used; for succulent food either yellow turnips or swedes are fed, and for the concentrated part of the ration linseed cake, wheat bran, crushed oats, ground barley, corn meal, pea meal, and bean meal in some combination, are fed by the best feeders. Some feeders steam or cook all of the grain and mix it with cut hay and pulped roots in preparation for feeding. Others prefer using all feeding stuffs in their natural state until the last few months, as by so doing they are able to make their animals eat more food when it is most needed. The amount of feed is regulated by the appetite of the animal, but the amount given is always a little less than the animal will eat, as all are very careful to avoid overfeeding so early in the season.

Regular exercise is provided at all times. During the months of May, June, and July the methods of management differ. Some very successful feeders leave their animals on grass a great deal of the time. When managed in this manner they get plenty of fresh air, succulent food, and exercise, which keeps them good on their feet and legs. Others equally as successful feeders stable their cattle from the middle of May until show time, and the only exercise they get is a half hour or more each day, when they are led out and walked by an attendant. In either instance the animals are fed a liberal grain ration which is composed of those feeding stuffs, such as crushed oats, ground barley, wheat bran, and linseed cake, which are not inclined to produce a heated condition of the system. On account of their heat-producing tendencies many feeders do not use corn meal, bean meal, or pea meal during the warm weather.

From August until show time the animals are fed on those feeding stuffs which will produce an abundance of firm flesh. For this purpose corn meal, barley meal, bean meal, pea meal, and crushed oats are very generally fed. Some linseed cake is also given, but its liberal use is claimed by many feeders to produce soft flesh. For firming up the flesh bean meal, pea meal, and crushed oats are claimed to be the most useful grains. Both the bean and pea meal should be at least one year old to insure good results. Roots are also fed; yellow turnips at first, but swedes are always fed as soon as they mature enough for feeding purposes, which is usually about the latter part of September or the first of October. The amount of succulent food is gradually reduced as the show season approaches, so that the animal will not be carrying too much belly. For roughage mixed hay, rye grass or clover hay is fed. Many feeders cut all the hay during the last month to reduce the amount of belly on the animal.

The best feeders all feed their animals at least four times per day and in many instances more frequently. During the last two months a great deal of time is spent in the cutting, steaming, and mixing of the feeding stuffs so as to make them more palatable, thus inducing the animal to eat more food. For this purpose treacle is used by nearly all of the feeders to sweeten the food, thus rendering it more palatable. A great deal of care is taken to keep the system cool and the blood pure. For this purpose a very successful feeder gives each of his show animals one-half an ounce of crude carbolic acid in a bran mash once a week during the last four months' feeding. All feeders emphasize very strongly the importance of regular exercise, especially the leading of the animal for half an hour or more each day, claiming that it aids very materially in the uniform development of firm flesh on all parts of the body.

Very complete information was secured pertaining to the methods of feeding practiced in the bringing out of all the most successful prize-winning cattle from Scotland at the leading British shows in 1904. As the methods were not very different, all the points of difference being mentioned in this connection, just one report will be given—that of the Shorthorn heifer Jewel, first in class, champion of the breed, and champion animal of any age or breed at the Smithfield Fat Stock Show in 1904, the very highest court of appeal in Great Britain.

During the months of December, January, and February, the daily ration was composed of 70 pounds turnips, 6 pounds cut rye grass hay, 3 pounds bran, 2 pounds ground barley, 1 pound bean meal, 1 pound pea meal, 2 pounds linseed cake, and 2 pounds of Thorley's cake. For the months of March, April, and May, the daily ration was composed of 70 pounds swedes, 7 pounds cut rye grass hay, 4 pounds bran, 1 pound bean meal, 1 pound pea meal, 3 pounds ground barley, 2 pounds linseed cake, and 2 pounds of Thorley's cake. During the months of June, July, and August, the daily ration was composed of green rape and tares, 7 pounds cut rye grass hay, 2 pounds bran, 1½ pounds bean meal, 1½ pounds pea meal, 4 pounds ground barley, 2 pounds linseed cake, and 2 pounds of Thorley's cake.

The September daily ration was composed of 40 pounds of yellow turnips, 30 pounds cabbage, 2 pounds bran, 2 pounds bran meal, 2 pounds pea meal, 3 pounds ground barley, 3 pounds Thorley's cake, and 1 pound linseed cake.

October daily ration was composed of 40 pounds yellow turnips, 30 pounds cabbage, 1 pound bran, 2 pounds bean meal, 2 pounds pea meal, 3 pounds ground barley, 3 pounds Thorley's cake, and 1 pound of oatmeal.

November daily ration was composed of 30 pounds yellow turnips, 30 pounds cabbages, 1 pound bran, 2 pounds bean meal, 2 pounds pea meal, 4 pounds finely ground oats, and 3 pounds of oatmeal.

During the first 6 months the heifer was fed four times per day; 6 a. m. cake, turnips, and hay; 10 a. m., mash, hay, and turnips; 4 p. m., cake, hay, and turnips; and at 7.30 p. m., mash, hay, and turnips.

During the months of June, July, and August, five times per day; 6 a. m., cake, hay, and green food; 9.30 a. m., mash, hay, and green food; 1 p. m., mash, hay, and green food; 4 p. m., cake, hay, and green food; and at 7.30 p. m., mash, hay, and green food.

During the months of September, October, and November she was fed five times per day; 6 a. m., cake, hay, and turnips; 9.30 a. m., mash, hay, and cabbage; 1 p. m., mash, hay, and turnips; 4 p. m., cake, hay, and cabbage; and at 7.30 p. m., mash, hay, and turnips.

THE UTILIZATION OF DAIRY BY-PRODUCTS AS FOOD.[1]

The important by-products of the dairy are skim milk, buttermilk, and whey, the aggregate value of which is enormous. At least 1,600,000,000 pounds of butter are made every year in this country. It is estimated that the skim milk and buttermilk resulting from the manufacture of this amount of butter contain in the aggregate over 1,000,000,000 pounds of protein, 60,000,000 pounds of fat, and 1,600,000,000 pounds of milk sugar. The whey produced in the cheese factories of the United States probably amounts to over 3,000,000,000 pounds, containing 31,000,000 pounds of protein, 9,000,000 pounds of fat, and 186,000,000 pounds of milk sugar. It is estimated that for each 100 pounds of whole milk used in butter making there are obtained as by-products 84 pounds of skim milk, containing 2.85 pounds of protein, 0.25 pound of fat, and 4.28 pounds of milk sugar. For each 100 pounds of 25 per cent cream used in butter making there are obtained 65 pounds of buttermilk, containing 1.95 pounds of protein, 0.32 pound of fat, and 3.12 pounds of milk sugar. For each 100 pounds of whole milk used in cheese making there are produced 90 pounds of whey, containing 0.9 pound of protein, 0.27 pound of fat, and 4.5 pounds of milk sugar. These by-products are imperfectly used at the present time.

---

[1] Compiled from New York Cornell Sta. Bul. 85; Vermont Sta. Bul. 155; Wisconsin Sta. Buls. 132, 211, Rpt. 1895, p. 134; U. S. Dept. Agr., Bur. Anim. Indus. Bul. 146, Circ. 161; Ontario Agr. Col. and Expt. Farm Ann. Rpts., 32 (1906), p. 308; 34 (1908), pp. 110, 147; 35 (1909), p. 124; Ontario Dept. Agr. Bul. 183; New England Farmer, 90 (1912), No. 54, p. 15.

As pointed out in previous bulletins of this series,[1] more use is made of the skim milk, which is now largely used on the farm and fed to calves, hogs, and poultry, and to a less extent used as human food. Considerable use is also made of skim milk for the preparation of casein used in the manufacture of various articles, and this use will probably increase. Large amounts of skim milk are used in the manufacture of cheese, condensed milk, sour-milk drinks, etc. It is safe to say, however, that thousands of dollars are annually wasted in many creameries and cheese factories because the buttermilk and whey are thrown away or put to inferior uses. In view of the high cost of foodstuffs of all kinds it is imperative that such valuable foodstuffs as these should not be wantonly wasted. A German authority states that under conditions in that country 25 cents will buy 538 food units in form of beef, 552 in poultry, 1,615 in whole milk, 2,311 in buttermilk, and 2,562 in skim milk. It is the purpose of this bulletin to point out especially some of the various ways in which buttermilk and whey may be utilized as human food.

UTILIZATION OF BUTTERMILK.

Buttermilk as a Beverage.

Buttermilk is a tempting beverage to many persons and when obtained as a by-product in butter making has a quality and flavor superior to the skim-milk buttermilk described in a previous bulletin of this series.[2] As a beverage the use of buttermilk in this country is increasing, for already in large cities there is a good demand for buttermilk in hotels, at lunch counters, and in bar rooms. It is reported that in some European cities buttermilk is to some extent replacing beer. An ordinary glass of buttermilk contains about as much nutriment as 2 ounces of bread, a good size potato, or a half pint of oysters.[3] The chemical composition of buttermilk varies more or less according to the composition of the milk from which it is made, but on the average it contains about the following percentages: Water, 91; protein, 3; fat, 0.5; carbohydrates, 4.8; ash, 0.7 per cent. It thus contains about the same food constituents as skim milk, but it has an added hygienic value because the protein is more easily digested than the protein in skim milk, and therefore is often prescribed by physicians for children and invalids, especially those suffering from intestinal trouble.[1]

---

[1] U. S. Dept. Agr., Farmers' Buls. 84, pp. 20, 21, 22; 92, p. 21; 133, p. 28; 202, p. 28; 233, p. 22; 381, p. 14; 384, p. 18. 405, p. 14; 430, p. 9; 457, p. 21.

[2] U. S. Dept. Agr., Farmers' Bul. 384, p. 406.

[3] U. S. Dept. Agr., Farmers' Bul. 363, p. 40.

Protein being the most costly of food ingredients is the one most likely to be lacking in inexpensive meals, and this is the nutrient which both skim milk and buttermilk supply in a cheap and useful form, and when taken with bread or used in cooking they form a very nutritious addition to the diet. Two and one-half quarts of skim milk or buttermilk contains about the same amount of protein as 1 pound of round steak, and costs about one-quarter as much. Two quarts of the milk has a greater nutrient value than 1 quart of oysters. The nutriment in the form of oysters would cost 30 to 50 cents, while the skim milk or buttermilk would have a value on the farm of from 2 to 4 cents.

Buttermilk Cheese.

Because buttermilk can not be made into cheese by the same methods used in making cottage cheese, the utilization of pure buttermilk for cheese making has until recently been regarded as impossible. Mixtures of skim milk and buttermilk are much easier to handle for making cheese than pure buttermilk, but the practical objection to the use of such a mixture is that every year fewer creameries have any skim milk, the separating being done on the farm.

In a recent bulletin of the Wisconsin Station, J. L. Sammis calls attention to the unnecessary waste of buttermilk and describes, for the first time, a method by which cheese can be made from the pure buttermilk, which has about the same value pound for pound as lean beefsteak, which sells at twice the price. Large numbers of city residents, to whom the prices of meat and eggs are objectionably high, should find in this cheese a palatable and economical food. The cheese can be eaten alone like cottage cheese, or it can be seasoned with salt, pepper, and paprika, or mixed with chopped pickles, olives, and nuts. It can also be used in salads. On account of its smooth texture it can be spread on bread like butter and can be used in sandwiches, either with or without butter. Bakers prefer buttermilk cheese on account of its smooth texture for the same purposes for which they formerly used cottage cheese.

The method of making this buttermilk cheese is described as follows:

> If the acidity of the buttermilk is as high as 0.5 per cent or higher when drawn from the churn, it will curdle properly after heating to 80° F., as directed below. If the buttermilk shows only 0.4 per cent acidity it will require to be heated to 90° instead of 80° to produce curdling. * * *

---

[1] Jour. Amer. Med. Assoc., 48 (1907), p. 1576.

The buttermilk is run directly from the churn into any convenient container to which heat can be applied. The wash water from the butter is not added. A steam-heated cheese vat, cream ripener or starter can is suitable. A tin-lined cream vat or an old weighing can (if free from rust) may be used, but it is necessary to provide a heating coil, made of two or three turns of one-half inch galvanized steam pipe. * * * Any container too heavy to tip to pour out the whey and curd should be provided with a gate for an outlet. On a small scale, a pail, a shotgun can, a new wash boiler, or any milk can, heated in a tub of hot water, can be used. No rennet is needed in making buttermilk cheese.

As soon as the buttermilk is in the vat, and usually before the butter is salted, it is convenient to heat the buttermilk to 80° as rapidly as possible, stirring enough to insure even heating of the vat contents. Then leave the vat undisturbed for about an hour, * * * as it needs no attention during this period of coagulation. The curd collects in a mass, surrounded by clear whey, and may float near the top or settle partly or wholly to the bottom, but the position of the curd is of no consequence.

Steam is now turned on and the vat heated rapidly to 130°, stirring enough to insure even heating. If desired to pasteurize the material, it may be heated to 140° or 150°. It is then left undisturbed for about an hour until the butter maker can spare a few minutes time to put the curd on the draining rack. It is well to keep the vat covered after the second heating in order that it may cool as little as possible, since the curd drains faster if warm, when put on the rack, than if cold It should not be reheated or stirred again before draining. The draining rack can be constructed by any carpenter, and is described below.

After the vat has stood at 130° to 140° for about an nour the draining cloth is placed in the rack, and this is pushed under the gate of the vat, which should stand near the floor drain. Upon examination of the vat contents, it will be found that the curd has shrunk in bulk, and has collected in a mass which is either floating at the surface or has settled entirely to the bottom. The next operation is to transfer the curd with as little whey as possible to the draining rack below the gate. This may be done in two ways.

First, if the curd is floating with clear whey beneath, upon opening the gate of the vat, the whey will run out first into the draining rack through the cloth and into the drain in the floor below, through which it can be drawn into the whey tank. As the whey runs out the layer of curd settles and finally runs through the gate and is caught in the cloth. By this means it is easy to get rid of most of the clear whey first and put the curd on the draining rack in the form of a thick mush. It is well to set a small pan under the gate on the draining cloth to prevent the curd from beating through the cloth at the place where it falls.

Second, in case the curd in the vat has settled to the bottom, leaving the whey above, it is best to put a strainer and siphon into the vat and draw out as much as possible of the clear whey without disturbing the curd. Afterwards the gate is opened and the curd, with the small amount of remaining whey, is run on to the draining rack.

In either case as soon as the curd is all on the rack it is covered and left undisturbed for half a day or over night to drain.

A most important factor in the success of the buttermilk cheese business is to see that the curd is drained equally dry, so as to appear of uniform consistency, day after day. * * * The portions of curd nearest the cloth drain most rapidly and may become quite dry while there is yet some whey standing on top of the curd, as shown in figure 1 at A. To observe this layer of dry curd next the cloth and also to hasten the draining the maker may lift up the cloth at one end of the vat, as shown in figure 1 at B. This will cause the dry curd to peel off clean from the cloth and settle in a pile in the middle of the rack. Lowering the cloth into place again will allow the loose whey to run down over the clean cloth surface and drain through more rapidly. The cloth should be raised at the other end of the rack also and the curd rolled into a pile at the middle, as shown in figure 1 at C.

As long as the curd is so moist that it will flow like a thick mush when the corner of the cloth is raised, it is too moist to suit the taste of most people. A well-drained curd can be taken out of the draining rack in large flat cakes, which retain their shape. If too moist the curd flows like wet mortar, and if too dry it crumbles apart when lifted. It should aways be drained dry enough before packing, so that there is no danger of whey separating from the curd in the package or danger of the product leaking out when the container, such as a covered butter tub, for example, is inverted. When properly drained the mass of curd can be taken out of the draining rack and molded with paddles into a tall form without losing its shape. * * * A curd would much better be drained longer than necessary rather than not long enough, because if too dry the consumer or maker can at any time easily restore the desired consistency by stirring in a little clean water, milk, or cream. On account of the smooth texture and fine buttermilk flavor of this product, it is not customary for the maker to add any cream to it, as it is necessary to do with skim-milk cottage cheese. The drier the curd the harder it is to stir in salt.

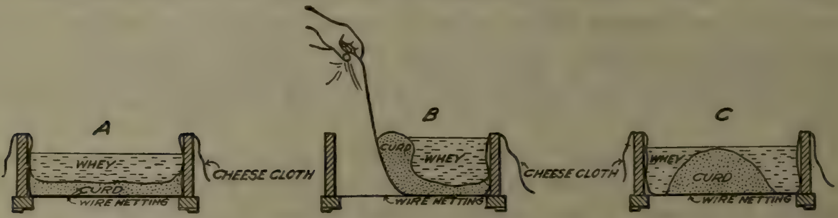


FIG. 1.—Three stages of the draining process. At *A* the curd is lying on the cheese cloth in the bottom of the draining rack; at *B* the cloth is lifted on one side to pile the curd in the center of the rack; and at *C* the operation is completed.

As soon as the curd is properly drained it is salted and packed immediately. The weight of salt needed is calculated either from the estimated weight of the buttermilk used or from the weight of the curd itself, which can be determined by lifting the curd altogether in the draining cloth and setting it on the platform scales. Use 1¼ to 1½ pounds of salt for 100 pounds of curd obtained, or for 800 pounds of buttermilk used. Weigh the salt carefully. Break up any lumps and sprinkle about half of the salt over the curd on the cloth in the rack. Stir it in well. Roll all of the curd over by raising the cloth at one side of the rack. Add the rest of the salt and stir in thoroughly. It is important that every pound of curd sold to consumers contain its proper proportion of salt.

Curd can be packed in lined or paraffined butter tubs for shipment or placed in a milk can in the refrigerator for local trade. When delivered in tubs or tin pails to retailers the main portion should be kept in a refrigerator, but a 1 to 5 pound sample should be put in transparent covered glass vessel, such as a pickle jar, on the counter, where customers can see and sample it. It should be plainly labeled, "Buttermilk cheese." For delivery to consumer in 1 or 2 pound lots it may be weighed into paper pails such as are used everywhere for oysters or ice cream, or into the neat paraffined paper single-service containers, * * * which are now obtainable, and which do not absorb moisture. It can be packed in cartons like butter prints.

The special apparatus used for making buttermilk cheese on a large scale, which is described in the bulletin, is inexpensive, and can be made by almost any butter maker. When only a small quantity is made daily the ordinary utensils of the creamery can be used.

Where only a few pounds of buttermilk cheese are made at a time, as on a farm or for home use, the buttermilk can be heated in a pail or in a clean new wash boiler on the stove. After the second heating, i. e., to 130°, if the curd has settled, the whey can be mostly poured off by tipping the pail, and the curd poured into a small cheesecloth bag to drain. If the curd is floating, it can be dipped off of the surface of the whey with a dipper or large spoon and put in the bag to drain. A small wooden draining rack a foot square and 5 or 6 inches deep, with the bottom made of one-fourth of an inch mesh galvanized or tinned iron wire netting and covered with cheesecloth, is useful for draining small amounts of buttermilk cheese, and for many other purposes in the household. * * *

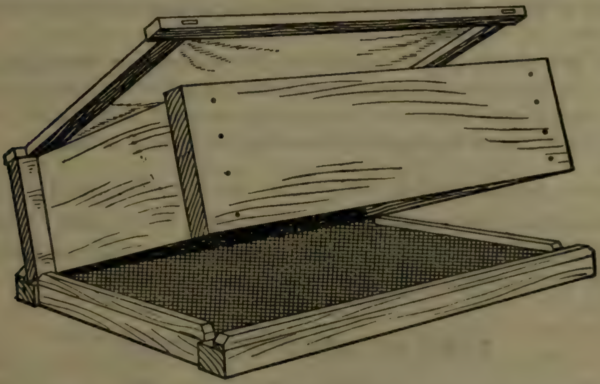


FIG. 2.—A draining rack suitable for a large creamery.

A more substantial draining rack for use in a large creamery is shown in figure 2, and can be made in the following manner: Make a square frame with mortised joints of 2 by 4 inch dressed lumber and fasten the wire netting on top with staples. This is the bottom of the draining rack. A little strip of molding is put around the outside of this frame on top to prevent the upper half from slipping out of place. The upper half is made of 2 by 12 inch dressed lumber mortised and spiked at the corners. A light wooden frame made out of 1 by 2 inch lumber with muslin or duck tacked on forms the lid for the draining rack. The wooden parts should be given 2 to 3 coats of linseed oil before being used, to prevent the absorption of water.

A piece of good quality cheesecloth is used to cover the sides and bottom of the rack and to hold the curd while draining. If it is necessary to sew two widths of cloth together, lap the edges about 1 inch and sew two seams about half an inch apart along the lap. * * *

Some kinds of butter color impart a faint color to the buttermilk and also to the cheese made therefrom. If a deeper color is desired in the cheese, this may be obtained by adding cheese color, such as used by Cheddar cheese makers, to the buttermilk before it is heated to 80°. One-half ounce of cheese color or more per 1,000 pounds of buttermilk may be used. * * *

If, for any reason, it is desired to make a very moist cheese from buttermilk, this can be done by proceeding exactly as directed above, but draining the curd for a shorter time until the desired consistency is reached and then salting and packing immediately. * * *

In addition to ordinary cleanliness it is entirely practicable to pasteurize the raw material used for making buttermilk cheese. Either the cream may be pasteurized before churning or the buttermilk may be heated to a pasteurizing temperature, 140°, for an hour during the cheese making process. Such pasteurization is sufficient to kill disease germs such as those producing tuberculosis, typhoid fever, dysentery, etc. * * *

Sold at 3 cents a pound, the 12 pounds of cheese obtained from 100 pounds of buttermilk add 36 cents to the income of the creamery, with an expense of less than 2 cents for steam, salt, etc., used in making. The time of the butter maker is not included here, because less than an hour per day is needed when the cheese is made daily either in large or small lots, and also because the work requires only 5 to 10 minutes at a time at convenient intervals during the day. * * *

Buttermilk from rich cream containing 50 per cent or more fat, as well as buttermilk from cream which was pasteurized when very sour, is not suitable for making buttermilk cheese. The curd from such buttermilk is always so fine grained that it runs through the draining cloth and is lost.

This cheese should find a ready sale among the foreign population of our cities, and even among the natives, when the cheese is sufficiently advertised to bring it to their attention. It ought to make a good grated cheese for cooking purposes.

PART BUTTERMILK CHEESE.

It is a common practice in European countries to mix buttermilk with skim milk or whole milk in making cheese of certain types. The methods of making varieties of such cheese are described by Doane and Lawson in a bulletin of the Bureau of Animal Industry as follows:

Hand Cheese.—Hand cheese is so named because it was molded originally into its final shape by hand. It is a sour-milk cheese, very popular among German races and manufactured in many countries.

The process of making varies in different localities, but in general is about as follows: The skimmed milk is mixed with buttermilk and put into a tinned vessel, where it is held at a favorable temperature for souring. When thick the curd is broken up by stirring and heated to 120° F. The cooking is continued for about 3 hours and for the first hour of this time is stirred thoroughly. After cooking the whey is drained off and the curd is put in a mold for cooling. It is then ground fine in a curd mill and salt is incorporated, and for some kinds caraway seed is added. The curd is then pressed into the desired shapes and sizes. The small cheeses are dried in a warm room and then transferred to the curing cellar, where they are kept on shelves until the ripening on the surface has commenced, when they are packed in boxes. The cheese has a very sharp, pungent odor and taste, which to most people unaccustomed to it is very disagreeable.

There are many local names for hand cheeses. among which are the following: Thuringia caraway cheese; Ihlefeld, made in Mechlenburg; Livlander, made in Russia; Olmützer Bierkäse; Dresdener Bierkäse; Satz, made in Saxony; Tyrol sour cheese; Berliner Kuhkäse, and Alt Kuhkäse.

Leather Cheese.—A method of utilizing creamery by-products in Schleswig-Holstein is in making a skim-milk cheese containing 5 to 10 per cent of buttermilk, the product being known as leather, leder, or Holstein dairy cheese.

The milk is set at from 95° to 100° F., and requires 25 to 35 minutes for coagulation. It is then broken up with a harp or a stirring stick, and is stirred with a Danish stirrer. When the particles are reduced to the size of peas the curd is piled up on one side of the vat or kettle and allowed to stand for 10 minutes. The whey is then dipped off. The curd is cut with a knife into pieces the size of the hand, put in a wooden or tin bowl, and pressed for one-half hour, when it is cut into pieces and run thorugh a cheese mill. It is then salted, put in a cloth, and again put in the press, where the pressure is gradually increased. The cheese is turned occasionally and a fresh dry cloth supplied. After 12 hours of pressing the cheese is put into the salt bath, where it is kept 40 to 48 hours. It is then transferred to the ripening cellar, where it is wiped with a dry cloth every day for about a week and thereafter twice a week, the ripening requiring about 4 months. The cured cheese has small eyes; it is made cylindrical, and is 4 to 6 inches in height and 10 to 12 inches in diameter. It weighs 15 to 25 pounds.

Danish Export Cheese.—This cheese is made in some of the creameries of Denmark to furnish an outlet for the skim milk and the buttermilk. In the process of manufacture as high as 15 per cent of fresh buttermilk is added to the skim milk. The mixture is set at 98° F. with sufficient rennet to coagulate in 25 minutes. The curd is carefully and evenly cut, stirred for a few minutes, dipped into forms having rounded bottoms, kneaded, pressed down, and finally covered with a board, upon which a weight is placed. Twelve hours later the cheeses are placed in a brine tank for 24 hours, when they are taken out and covered with salt for a short time. They are then transferred to the ripening room, where the temperature is about 55°, and are turned and wiped with a cloth every day for 5 weeks. The cheeses are cylindrical in shape and are small and flat.

Manur Cheese.—This cheese is made in Servia from either sheep's or cow's milk. The milk is first heated to the boiling temperature and then cooled until the fingers can be held in it. A mixture of buttermilk and fresh whey with rennet is added. The curd is lifted from the whey in a cloth and allowed to drain, when it is kneaded like bread, lightly salted, and dried.

Pultost Cheese.—Pultost, also called Knaost, is made usually from sour milk, but it may be made with rennet. It is a Norwegian product, and is made in private dairies in the mountains of that country. The milk is placed in a kettle and if not sour enough to coagulate on warming the acidity is increased by the addition of buttermilk. When sufficient acid has developed the milk is warmed to 113° F. The curd is broken up with a scoop and stirred to keep it from matting together while it is being heated to 140°. It is then dipped and ground up fine. Buttermilk is added and the whole is thoroughly kneaded and put into troughs, where it is covered with a cloth. It is allowed to stand for three days with occasional stirring.

> **Sap Sago Cheese.**—Sap Sago is a small, hard, green cheese flavored with the leaves of a species of clover; it is shaped like a truncated cone, 4 inches high, 3 inches in diameter at the base, and 2 inches at the top. * * *
>
> The skimmed milk from which this cheese is made is not allowed to become sour enough to coagulate on heating, as it would make too hard a curd. The milk when it has reached the right acidity is heated to the boiling temperature while being stirred. Cold buttermilk is then added, as is also some whey having a high percentage of acidity. The material coagulating on the surface is skimmed off. The milk is then stirred while sufficient acid whey is added to precipitate the casein. When too little whey is used the curd is too soft, and when too much is used it is too hard. The curd is dipped with a skimmer and spread out to cool and then put in boxes and allowed to drain and ferment. The box is kept at a temperature of about 60° F., and pressure is applied by weighting with stones. Ripening is allowed to continue for 3 to 6 weeks. If the temperature of the room is too high or there is not sufficient pressure, too rapid and strong fermentation results. This curd is used for making the finished product, but the cheese is seldom finished where the curd is made. The curd is ground in a mill, and every 100 pounds of cheese contains 5 pounds of salt and 25 pounds of dried *Melilotus cœrulea*, an aromatic clover which is grown in the Canton of Schweiz for the purpose. The ground material is worked up into a dough and is forced into molds lined with linen cloth, and the name of the manufacturer is stamped on the large end. The mold is then emptied and refilled. The cheeses are dumped promiscuously into a large cask holding about 200 pounds. A comparatively small quantity is shipped into this country. It sells at a low price and is usually grated.

It should be possible to use buttermilk as well as skim-milk cheeses to take the place of Parmesan and similar cheeses, some of which are imported in large quantities and sell for high prices.

Buttermilk Cream.

The preparation of buttermilk cream is described by J. L. Sammis, of the Wisconsin station, as follows:

> Buttermilk cream has the consistency of ordinary thick cream and [is] quite smooth and free from lumps or grains. It is made in the same general manner as described for buttermilk cheese, but with this difference, that at the second heating the temperature is raised only to 100° instead of 130°. The curd is put to drain at this lower temperature and therefore drains more slowly. Too long heating or use of too high a temperature before draining makes the drained product dry and granular. Before packing for sale, the buttermilk cream taken from the draining cloth should be stirred up well to give it a uniformly smooth appearance. * * *
>
> For some time the buttermilk was made into buttermilk cream at the Wisconsin station and offered for sale alongside of the regular buttermilk cheese, and it was observed that the great majority of consumers chose the "cheese" rather than the "cream." Consequently the making of buttermilk cream was discontinued.

Condensed Buttermilk.

Condensed buttermilk is made to some extent in Europe and ought to become an important commercial food product. It is sometimes also sold in powdered form.

Buttermilk Sherbet.

Buttermilk sherbet is considered a delicacy by some, and is a valuable dish for invalids. R. M. Washburn, of the Vermont station, states that—

> This new dish has merit and should become popular, especially in warm weather. It is made very much as are other sherbets, except that fresh, tart buttermilk is used in place of water, no lemons or other acid-bearing ingredient being required. Made in a small way, the following recipe has been found to give excellent results: Two quarts fresh, tart buttermilk; 1¼ pounds sugar; 1 large orange or 2 small ones; 3 teaspoonfuls gelatin. It is frozen in the same manner as is ice cream, save that no attempt is made to increase its volume materially. This sherbet is so rich in sugar that it will melt at a relatively low temperature, and consequently it will often be found slushy if held at the ordinary holding temperature for ice cream.

UTILIZATION OF WHEY.

Whey, the residue from cheese making, is used to some extent as food for man and beast and for various purposes in the arts. Chemical analysis of whey shows that on an average it has about the following composition: Water 93 per cent, albumin (protein) 1 per cent, fat 0.3 per cent, and carbohydrates (sugar) 5 per cent. Although containing considerable nutritive material, whey has less food value than skim milk or buttermilk, but is occasionally useful as a mild laxative drink for invalids. Its dietetic value is more fully recognized in Europe than in this country. In Finland whey is mixed with water or milk and used as a drink for man or beast, but in the United States in many cheese factories the whey is allowed to go to waste. Of the 3,000,000,000 pounds or more of whey annually produced in the United States only about 166,000,000 pounds are reported to be utilized. In some localities whey is used for feeding pigs. Sometimes the whey is evaporated, and the sugar thus obtained is sold to the trade. The residue from the sugar has value as a fertilizer and has been used for this purpose. Occasionally the whey is run through a separator and the fat obtained is made into whey butter.

Whey Butter.

The manufacture of butter from the fat in whey as a by-product in cheese making is a common practice in Europe, but has been undertaken in only a few factories in the United States, although experiments at the Cornell and Wisconsin stations by the Dairy Division of this department have shown that it is profitable to do this in a large plant when butter is high in price. The results of the experiments of the dairy division of this department in making whey butter at a Wisconsin cheese factory may be summarized as follows:

The yield of butter for different months varied within comparatively wide limits. For June it was 2½ pounds per 1,000 pounds of milk, while for October it was 3½ pounds. The daily variation was even greater, varying from 2 to 5 pounds of butter per 1,000 pounds of milk. To secure the maximum yield it was necessary to save the drippings from the milled curds. In one instance 58 pounds of whey, which tested 11 per cent fat, dripped from the milled curd of a 5,000-pound vat of milk.

In making whey butter it was found to be the best practice to run the whey directly from the vats to a thoroughly sanitary tank and separate with as little delay as possible. A pump is necessary for elevating the whey from the tank to the separator. It is believed that from 20 to 30 per cent of starter improves the flavor. The butter made from whey is better than a large part of the butter commonly sold to retail trade, but the drippings from the milled curd give the butter a characteristic flavor somewhat difficult to describe, which brings down the theoretical score, although it does not seem to injure the butter for table use. Whey butter is apparently a little softer than the regular creamery butter, but a number of tests showed that this was not due to excessive moisture. The butter sold to the local trade brought a little less than the best creamery butter, while the portion shipped to Chicago sold for 2 to 3 cents under the regular price for creamery butter.

It is thought that for factories having a maximum daily run of 10,000 pounds or more the making of whey butter would be a profitable undertaking for both the factory and the farmer. A cheese factory in which the Dairy Division of this department has been interested paid to the farmers about $1,000 for their share of the butter in one year, and this sum was a clear gain to the farmers. In addition to this, it is pointed out that the patrons of the cheese factory can buy the butter at a lower price than creamery butter shipped in and retailed from local stores.

At the Ontario Experiment Station the average yield of butter per 1,000 pounds of whey was about 2½ pounds, and it is thought that it is profitable to make whey butter only in large factories or where conditions are favorable for centralizing the whey cream. The quality of the butter was fair and possessed fairly good keeping qualities; in fact, it was equal to average creamery butter when the whey was pasteurized; but that made from unpasteurized cream and allowed to ripen naturally was poor in quality and went off in flavor badly at the end of six months. The grain and color of the pasteurized lots seemed to improve with keeping.

Albumin or Whey Cheeses.

In European countries the albumin is often utilized in making whey cheese. In Scandinavia these cheeses are known under the name of "mysost." The type generally made in southern and central Europe, known as "Ziger," is prepared as follows:

Ziger.—This is a cheese made from the whey obtained in the manufacture of other cheese. It consists principally of albumin, but where no effort is made to separate the fat from the whey the product may contain a relatively high proportion of fat. It is a cheap food product made in all the countries of Central Europe. Among the many names applied to it are Albumin cheese, Recuit, Ricotte, Broccio, Brocotte, Sérac, and Ceracee.

In the manufacture of this product an effort is sometimes made to remove the fat remaining in the whey, but in most cases the fat is allowed to remain. Where it is desired to skim the whey a small portion of very sour whey, previously prepared, is added to the sweet whey and the whole is heated to 160° to 175° F. for a few minutes, when the fat collects on the surface and can be skimmed off. Following this a greater portion of sour whey is added and the whey is then heated nearly to the boiling point, when the albumin is precipitated in a flocculent condition and rises to the surface of the whey. When the whey is not in normal condition the albumin may be precipitated in a powdery mass. This is often prevented by adding 3 to 5 per cent of buttermilk to the whey before the last heating. The casein of the buttermilk is precipitated, the albumin being carried with it. It is considered that this addition of casein injures the product. The albumin when skimmed from the whey is salted and packed in a vessel and may be covered with whey.

A so-called formed Ziger cheese is made by molding the half-dried albumin into squares which may be still further dried. Some of these have local names, such as the Hudelziger made in the Canton of Glarus, Switzerland.

In Vorarlberg the albumin is skimmed from the whey, allowed to cool, placed in cheese cloth, and subjected to increasing pressure in an Emmental cheese press. After 24 hours the cheese is put into a salt bath, to which sweet cider and vinegar are sometimes added.

A mixture of Ziger and cream prepared in the Savoy is known as Gruau de Montagne. An albumin cheese made from the whey of goat's-milk cheese in the Canton of Graubünden, Switzerland, is known as Mascarponi.

There are several cheese factories in New York and Ohio which make cheese especially for Italian trade that calls for varieties similar to those that Italians are accustomed to in their home country. One of these varieties is an albumin cheese, known to the trade as "Ricotte." It is made by utilizing the whey drawn from the curd used for making a skim-milk cheese. The whey is heated to about 200° F., and the coagulated albumin is skimmed out and put into perforated tin cylinders about 6 inches in diameter and slightly tapering. These are set one into another for pressure. The albumin block is then rubbed with salt and set on a shelf to dry for several weeks. A steam-heated kiln may be used to facilitate the drying. The cheese is then wrapped in parchment paper and packed in barrels for shipment.

Mysost.—Mysost is made from whey and is a product of Norway, Sweden, and Denmark, and to a very limited extent of the United States. It has a light-brown color, a buttery consistency, and a mild, sweetish taste.

The method of manufacture is as follows: As soon as the curd of the regular cheese is removed from the whey, the whey is strained and is put in a kettle or large pan over the fire and the albuminous material which rises to the surface is skimmed off. The whey is evaporated as rapidly as possible with constant and thorough stirring. When it has reached about one-fourth its original volume the albumin previously skimmed off is returned and stirred thoroughly to break up all possible lumps. When the whey has attained the consistency of thickened milk it is poured quickly into a wooden trough and stirred with a paddle until cool to prevent the formation of sugar crystals. This can then be molded into the desired form. In this country it is usually made into cylindrical shapes and wrapped in tin foil.

In recent years it has become the custom to add some cream to the whey cheese to make it considerably richer in fat and casein. This new variety is called "fetost."

For a full discussion of the nutritive value and place in the diet of milk and its products the reader is referred especially to Farmers' Buls. 363 and 487 of this department.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

1920

1434 Issued February 26, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 487.

CHEESE AND ITS ECONOMICAL USES IN THE DIET.

BY

C. F. LANGWORTHY, Ph. D.,
Chief of Nutrition Investigations, Office of Experiment Stations,

AND

CAROLINE L. HUNT, A. B.,
Expert in Nutrition, Office of Experiment Stations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 16, 1912.

Sir: Since cheese is one of the important agricultural products of the United States and a foodstuff used in a larger or smaller quantity in nearly every American home, it seemed desirable to study its relative nutritive value and the ways in which it may be prepared for the table.

Although it is so generally liked, there seems to be a widespread belief that it is not well digested and that it is a cause of physiological disturbances. Neither of these beliefs is substantiated by the results of the extended series of digestion experiments undertaken as part of the nutrition investigations of the Office of Experiment Stations. Indeed, cheese was found to be very thoroughly digested, ranking with other staple foods in this respect. Moreover, experiments made with the respiration calorimeter did not indicate that it was less easy of digestion than a comparable amount of meat.

In the studies of the digestibility of cheese the Bureau of Animal Industry cooperated with the Office of Experiment Stations and was also of great assistance in securing, for experimental purposes, cheese made and cured under controlled conditions. Supplementing the experiments as to the nutritive value of cheese, many tests were made of methods of preparing cheese for the table, the main purpose being to suggest dishes and combinations of such a character that the cheese might replace other nitrogenous material and fat when this seemed desirable.

The bulletin was prepared by C. F. Langworthy, chief of nutrition investigations, Office of Experiment Stations, and Miss Caroline L. Hunt, who has had wide experience in the study of both scientific and practical problems in nutrition. The recipes were collected from many sources and in the majority of cases were studied experimentally by Miss Hunt.

Acknowledgment should be made to teachers of home economics in agricultural colleges and other educational institutions, to housekeepers, and others who have supplied data of great value in preparing the bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

- Introduction ... 5
- Cheese making ... 7
- Kinds of cheese used in American homes ... 8
  - Cheddar and American full-cream cheese ... 8
  - English dairy cheese ... 9
  - Soft cream cheeses ... 9
  - Neufchâtel cheese ... 9
  - Parmesan cheese ... 10
  - Sap Sago ... 10
  - Gorgonzola and Roquefort ... 10
  - Potted or sandwich cheeses ... 10
  - Swiss cheese (Emmentaler, Gruyère, etc.) ... 10
  - Edam cheese ... 10
  - Brie and Camembert cheese ... 11
  - Cottage cheese ... 11
- The care of cheese in the home ... 11
- Cheese as a food ... 11
- The flavor of cheese ... 12
- Composition of cheese and some other foods compared ... 12
- Nutritive value and cost of cheese and some other food materials ... 14
- Amounts of protein and energy obtained for 10 cents expended for cheese and other foods at certain assumed prices per pound ... 14
- The digestibility of cheese ... 15
- The use of cheese in the diet ... 16
- Bill-of-fare making with cheese as the central food ... 17
- Homemade cheese ... 19
  - Curds and whey ... 19
  - Cottage cheese ... 19
  - Sour-cream cheese ... 20
  - Uncooked curd, or French cottage cheese ... 20
  - Junket ... 20
  - Buttermilk cheese ... 20
  - Buttermilk cream ... 21
  - Devonshire cream ... 21
- Cheese dishes and their preparation ... 21
- Cheese dishes which may be used in the same way as meat ... 22
  - Cheese sauce No. 1 ... 22
  - Cheese sauce No. 2 ... 23
  - Cheese sauce No. 3 ... 23
  - Cheese sauce No. 4 ... 23
  - Cheese fondue No. 1 ... 24
  - Cheese fondue No. 2 ... 24
  - Boiled fondue ... 25
  - Rice fondue ... 25
  - Corn and cheese soufflé ... 25
  - Welsh rabbit ... 25
  - Tomato rabbit ... 26
  - Green corn, tomato, and cheese ... 26
  - Macaroni and cheese No. 1 ... 26
  - Macaroni and cheese No. 2 ... 26
  - Macaroni and cheese and tomato sauce ... 26
  - Italian macaroni and cheese ... 26
  - Cheese and macaroni loaf ... 27
  - Baked rice and cheese No. 1 ... 27
  - Baked rice and cheese No. 2 ... 27
  - Baked crackers and cheese No. 1 ... 27
  - Baked crackers and cheese No. 2 ... 28
  - Cheese rolls ... 28

Cheese dishes which may be used in the same way as meat—Continued.

Page.
Boston roast 28
Pimiento and cheese roast 28
Nut and cheese roast 28
Cheese and spinach roll 28
Vegetable and cheese rolls 29
Cheese used in the stuffing of meat 29
Creamed cheese and eggs 29
Baked eggs with cheese 29
Scrambled eggs with cheese 29
Swiss eggs 29
Cheese omelet No. 1 30
Cheese omelet No. 2 30
Cheese omelet No. 3 30
Breakfast cereals with cheese 30
Oatmeal with cheese 30
Cheese with mush 31
Fried bread with cheese No. 1 31
Fried bread with cheese No. 2 31
Roman gnocchi 31
Cheese soufflé 31
Cheese soufflé with pastry 31
Cheese croquettes 32
Fried cheese balls 32
Cheese soups and vegetables cooked with cheese 32
Milk and cheese soup 32
Cheese and vegetable soup 32
Scalloped potatoes with cheese No. 1 33
Scalloped potatoes with cheese No. 2 33
Scalloped cabbage or cauliflower with cheese 33
Cheese with potato puffs 33
Potatoes with cheese sauce 33
Cheese salads, sandwiches, and similar cheese dishes 33
Cheese with salads 33
Plain cheese salad 34
Olive and pimiento sandwich or salad cheese 34
Cheese and tomato salad 34
Cheese and pimiento salad 34
Cheese jelly salad 34
Cheese salad and preserves 34
Deviled eggs with cheese 34
Cheese and celery 35
Buttermilk cream salad dressing 35
Buttermilk cream horseradish salad dressing 35
Cheese sandwiches 35
Cheese and anchovy sandwiches 35
Pimiento, olive and cheese sandwiches 35
Cuban sandwiches 35
Toasted cheese sandwiches 35
Cheese pastry, cheese sweets, and similar dishes 35
Cheese pastries and similar dishes 36
Cheese biscuits No. 1 36
Cheese biscuits No. 2 36
Cheese drops 36
Cheese wafers 37
Cheese relish 37
Cheese straws 37
Salad biscuit 37
Cheese gingerbread No. 1 37
Cheese gingerbread No. 2 37
Cheese custard 37
Cheese cakes 37
Brown Betty with cheese 38
Conclusion 38

CHEESE AND ITS ECONOMICAL USES IN THE DIET.

INTRODUCTION.

Cheese is believed to be the oldest of the dairy products and the first form in which milk was preserved for future use. One may conjecture that it owes its origin to the accidental storing and ripening of sour milk curd. Although it has been a staple food with many races for uncounted years, there is a widespread belief that it is suitable for use chiefly in small quantities as an accessory to the diet, and that in large quantities it is likely to produce physiological disturbances. We are inclined, therefore, to think of those who make cheese one of the chief articles of their diet as being driven to this course by necessity rather than being led to it by choice.

Because of these opinions extensive studies have been carried on as a part of the Department Nutrition Investigations, of the food value, thoroughness of digestibility, ease of digestion, physiological effect, and special character of cheese as food as well as of methods which are followed in preparing it for the table. The conclusion drawn from this extended study is, in brief, that cheese properly prepared and used is not generally a cause of physiological disturbances, and that it may easily be introduced into the bill of fare in such quantities as to serve as the chief source of nitrogenous food and may be made a substitute for other nitrogenous foods when such substitution is desired.[1] The results of these studies have been brought together in this bulletin with a view to making them helpful to all interested in the subject, but particularly to housekeepers.

From the standpoint of the housekeeper, cheese is of importance because of its high nutritive value, particularly its high percentage of protein or muscle-forming materials, because of the ease with which it can be kept and prepared for the table, and because of its appetizing flavor and of the great variety of ways in which it can be served.

From the point of view of agriculture cheese is an important commodity. The latest census figures available show that considerably over 300,000,000 pounds are made yearly in the United States, the value of the product being nearly $29,000,000, and the amount of money invested being over $6,000,000. The figures quoted are from the census report which first separated the details of the cheese industry from those of the butter and condensed-milk industries. From earlier statistics available, however, it is fair to judge in a general way of the development of any one of these industries from the figures given for the three industries combined. In general, these figures show that there was a great leap forward in the three industries in the decade between the years 1880 and 1890, and that since that time there has been a continuous, steady, healthy growth in the business of cheese making.

---

[1] U. S. Dept. Agr., Yearbook 1910, p. 350.

As might be expected, the amount of the product and the amount of money invested have increased more rapidly than the number of men employed, indicating that, as in most manufacturing industries, labor-saving devices and other improvements have reduced the proportion of physical labor required.

As regards the kind of cheese made in the United States, the figures show that of the amount produced in 1905 approximately three-fourths was what is known to the trade as standard factory cheese, or what is usually known to the retail purchaser as American cheese. A very small per cent—1.1 per cent—was skim-milk cheese, the remainder being American modifications of certain important foreign brands, Neufchâtel, Camembert, and others.

From the standpoint of the retail dealer, cheese is important because it is a convenient article to handle. Its percentage of nutrients being high and its percentage of water low, it is not bulky. It is comparatively easy, too, to preserve in good condition. The difficulty of cutting exact amounts called for by customers may be considered the chief inconvenience. Efforts have been made to obviate this difficulty by making small cheeses. Experiments have been reported from the Oregon Experiment Station [1] on the canning of cheese in pound lots; and from the Wisconsin Experiment Station [2] in making cheese prints like those in which butter is commonly sold. In some of the factories cheeses weighing about 5 pounds and having the same shape as the larger cheeses are made. These are convenient for use in families where a large amount of cheese is eaten, and furthermore cheese in such form dries out and spoils less quickly and easily than cheese cut in wedge-shaped slices, as it usually is when sold by the pound. A convenient way of keeping and using such cheese is given on page 11.

The sale of cheese in pots is another way of overcoming the difficulty ot cutting exact amounts. Cheese thus prepared is, as a rule, softened by the addition of butter fat or other fat, with the idea of making it of such consistency that it can be used like soft cheeses.

There is something to be said also of the value of cheese to that not inconsiderable number of individuals who must occasionally cater for themselves—those men and women in business life, for example, who find it convenient neither to carry lunches nor to go to restaurants. For these, cheese offers a convenient way of supplying the necessary protein, for it can usually be obtained in good condition in any neighborhood. Combined with crackers, some of the ready-cooked cereals, or bread, and with fruit, it makes a fairly well-balanced meal.

---

[1] Oregon Sta. Bul. 78.

[2] Wisconsin Sta. Rpt. 1901, p. 132; U. S. Dept. Agr., Farmers' Bul. 166.

CHEESE MAKING.

Though the chief points in the manufacture of cheese are well known, and are discussed in detail in other publications[1] of this department, it may not be out of place to review them here. Cheese is made ordinarily from whole milk, and most of the kinds best known in the United States from cows' milk. In every 8 parts of milk by weight there is approximately 1 part of solid nutrients, the remainder being water. For our present purpose we may think of the nutrients as being equally divided into three groups—protein substances (casein and albumin principally), fat, and milk sugar. In the process of cheese making the casein, which constitutes more than three-fourths of the proteids of the milk, is precipitated by rennet, forming a curd. Most of the fat attaches itself to this curd. The curd is broken up, and the whole is heated to a temperature between 96° and 108° F. The whey is drained off and carries with it most of the milk sugar and the albumin. The curd is salted and pressed. It is kept for several weeks or longer in a cool place, where it "ripens," developing flavors through the action of bacteria or other micro-organisms, and also undergoing certain other marked changes.

The average cheese while fresh and moist contains proteids and fat in much the same ratio as that in which they are found in the milk. More than one-fourth its weight is proteid, about one-third fats, and one-third water. There are always present small amounts of albumin and sugar which have clung to the curd. Owing to the addition of salt, the percentage of mineral matter is high compared with that of most other foods.

In ripening, cheese changes in texture and its original pastiness gives away to a somewhat granular consistency in some types, or to a waxy or a buttery consistency in others.

The above brief outline refers only to the essentials of cheese making. In practice, there are many variations with respect to the kind of milk used, the proportion of butter fat or cream retained in or added to the milk, with respect to the methods followed in separating, preparing, seasoning, and handling the curd, and to the handling and ripening of the cheese. It follows that there is an almost endless number of cheeses with different names and of different appearance and flavor.

---

[1] U. S. Dept. Agr., Farmers' Buls. 166, 225, 244; Bur. Anim. Indus. Buls. 105, 146.

Cheese making was formerly a home or farm industry, but is now, in the United States at least, very largely a commercial enterprise carried on in factories. It differs from many industries in that the factories are almost always located in the country or in the smaller towns rather than in large cities, this being more true of cheese making than of the manufacture of potted cheeses or other special articles, which has become a large industry. It is worthy of mention in this connection that the making of cheese crackers and other bakers' goods in which cheese is an ingredient has developed into an important part of the baking trade.

KINDS OF CHEESE USED IN AMERICAN HOMES.

The American factory cheese—the so-called American cream cheese—is of the English Cheddar type, and as it is the most commonly used of all the commercial varieties in the United States, may be taken as a standard. Other types are, however, well known, particularly in cities and large towns where there are well-stocked markets and stores, and it is interesting to note also, at least briefly, the characteristics of some of them. Full descriptions of a very large number of cheeses (about 250 in all) may be found in an earlier bulletin of this department.[1]

CHEDDAR AND AMERICAN FULL-CREAM CHEESE.

Cheddar cheese—named from the English village where it originated—is a comparatively old type of cheese, very popular in England and also in the United States. The name is now more fitly applied to a process than to any particular shape.

Cheddar cheese is made from sweet cows' milk, which may be skimmed, partly skimmed, or unskimmed. If made from unskimmed milk the cheese is called "full cream." If cream is removed the the cheese is designated "part-skim" or "skim," as the case may be.

Cheese of Cheddar type as made in the United States is perhaps most often marketed in large, flat, round forms, 13 to 16 inches in diameter, about 5 or 6 inches in height, and weighing 26 to 32 pounds each, though other shapes and sizes are also fairly common. It is usually pale to darker yellow in color, though it may be white when uncolored. When fresh it is mild in flavor, but when well ripened has a characteristic and sharp taste. The new cheese is soft, though not waxy, in texture, and may be easily shaved or broken into small pieces. When well ripened it may be finely grated.

These characteristics, together with its distinctive and peculiar flavor and its wide distribution in the markets, are qualities which help to make it the variety most commonly used in the United States.

---

[1] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 146.

Sage cheese is a variety of Cheddar cheese, which is flavored with sage and is further characterized by the green mottled appearance formerly due to bits of sage leaf but now generally obtained in another way.

ENGLISH DAIRY CHEESE.

From the standpoint of the cook who frequently wishes to use grated cheese this variety is important. Though made in much the same way as Cheddar, it differs from it, in that the curd is heated to a somewhat higher temperature, and the cheese is therefore harder. It commonly sells for somewhat more per pound than the standard or American factory variety and is likely to be found only in the larger markets.

SOFT CREAM CHEESES.

Cream cheese true to name is made from rich cream thickened by souring or from sweet cream thickened with rennet. The whey is removed by draining. It is then covered, salted, and turned occasionally, being ready for market in 5 to 10 days. A variety is also made with rennet from cream of low fat content, as well as a number of other special sorts much more common in France than in the United States.

The term "cream cheese," however, is an elastic one and includes many varieties which are sold under special trade names. Such cheese is common in most markets.

Soft cream cheese differs from standard cheese, so far as composition is concerned, in having more water and fat and less protein, water usually making up about one-half of the total weight. It differs also in being much more perishable. These cheeses commonly sell for 10 or 15 cents each, which is about 40 to 50 cents a pound.

Of late there have been on the market varieties of such cheese or of Neufchâtel, made by combining the cheese with chopped pimiento. These bring a relatively high price in market and may be easily prepared at home if this seems more convenient. (See p. 34.)

NEUFCHÂTEL CHEESE.

This very popular variety—named from a town in northeastern France—is similar in appearance and in the way it is marketed to soft cream cheese. It is made either from whole or skim milk curdled with rennet. After draining and pressing, it is kneaded thoroughly, formed into small rolls or blocks, and then ripened until special molds develop, which requires about four weeks. It is then wrapped in tinfoil and marketed.

PARMESAN CHEESE.

This is a name given outside of Italy to a very hard cheese which in that country is said to be known as Grana, a name given because of the granular appearance which it has after it has been broken. It is sometimes sold in grated form and brings a relatively high price, but is more commonly sold ungrated. When well made it will keep for years and may be easily broken and grated. It is very generally used in Europe for serving with soups, for seasoning macaroni, and for other similar purposes, and is quite common in American markets.

SAP SAGO.

This is a skim-milk cheese made in Switzerland, which is suitable for grating. It contains, for every 4 pounds of cheese, 1 pound of a clover (*Melilotus cæruleus*) grown in Switzerland. It is greenish in color and has an unusual flavor. It is not high-priced.

GORGONZOLA AND ROQUEFORT.

These are highly flavored cheeses characterized by the presence of molds through their entire mass. Roquefort is made from the milk of sheep; Gorgonzola, from cows' milk.

POTTED OR SANDWICH CHEESES.

Ordinary cheese is often mixed with butter or oil in the proportion of 5 parts of cheese to 1 of butter or oil, by weight. The mixture is sometimes seasoned with mustard or with curry powder. Such cheeses, unseasoned or seasoned, are on the market in great variety. Potted cheese may be easily prepared at home if the housekeeper wishes to take the trouble.

SWISS CHEESE (EMMENTALER, GRUYÈRE, ETC.).

This term as used in America is somewhat vague. Different names are given to the varieties according to the districts of Switzerland in which they are made, but they are all similar and characterized by a mild, sweetish flavor and the presence of large holes or "eyes." Foreign and domestic brands are to be found in most markets. They are suitable for cooking purposes, as well as for use without being cooked, and are much used in this way in Europe and well known and liked in the United States.

EDAM CHEESE.

This is a cheese made in Holland. It is molded in spherical form, and the outside is usually dyed red. It is usual in this country to cut off a section of the top, which serves as a lid, and to scoop out the inside as needed. In Holland it is frequently served in slices, particularly when it is fresh. Edam cheese is seldom used in cookery in American homes, though thrifty housewives, after the greater part of the cheese has been removed, often stuff the hollow shell with cooked and seasoned macaroni, rice, or something similar and bake.

BRIE AND CAMEMBERT CHEESE.

These are very soft rennet cheeses of foreign origin and of somewhat smaller nutritive value than standard cheese, and of strong flavor and odor. They are not often used in cookery, but are used as an accompaniment to other foods. The Bureau of Animal Industry and the Connecticut Storrs Experiment Station in cooperation have experimented with the making of Camembert cheese with marked success, and have published a full account of the work.[1]

COTTAGE CHEESE.

Cottage cheese and other sour milk and cream cheeses, junket, Devonshire cream, and a number of other cheese-like products are described in the section which deals with homemade cheese.

THE CARE OF CHEESE IN THE HOME.

One of the best ways of keeping cheese which has been cut is to wrap it in a slightly damp cloth and then in paper, and to keep it in a cool place. To dampen the cloth, sprinkle it and then wring it. It should seem hardly damp to the touch. Paraffin paper may be used in place of the cloth. When cheese is put in a covered dish, the air should never be wholly excluded, for if this is done, it molds more readily.

In some markets it is possible to buy the small whole cheeses mentioned on page 6. These may be satisfactorily kept by cutting a slice from the top, to serve as a cover, and removing the cheese as needed with a knife, a strong spoon, or a cheese scoop. It is possible to buy at the hardware stores knobs which inserted in the layer cut from the top make it easy to handle. The cheese below the cover should be kept wrapped in a cloth.

CHEESE AS A FOOD.

Cheese is used in general in two ways—in small quantities chiefly for its flavor and in large quantities for its nutritive value as well as for its flavor. Some varieties of cheese are used chiefly for the first purpose, others chiefly for the second. Those which are used chiefly for their flavor, many of which are high priced, contribute little to the food value of the diet, because of the small quantity used at a time. They have an important part to play, however, in making the diet attractive and palatable. The intelligent housekeeper thinks of them not as necessities, but as lying within what has been called "the region of choice." Having first satisfied herself that her family is receiving sufficient nourishment, she then, according to her means and ideas of an attractive diet, chooses among these foods and others which are to be considered luxuries.

---

[1] U. S. Dept. Agr., Bur. Anim. Indus. Buls. 71, 98, 109, 115, 120, Circ. 145; Conn. Storrs Sta. Buls. 35, 46, and 58.

Those cheeses, on the other hand, which are suitable to be eaten in large quantities and which are comparatively low priced are important not only from the point of view of flavor, but also from the point of view of their nutritive value. Among such cheeses the one which, as noted above, is known to the trade as standard factory cheese and to the housewife as American cheese stands out preeminently. Therefore when the word "cheese" is used without specification in the following pages it may be taken to refer to this particular variety.

THE FLAVOR OF CHEESE.

Cheese owes its flavor to the fatty acids and their compounds which it contains and to ammonia-like bodies formed during ripening from the cleavage of the casein, to salt added to the curd, and in some varieties, like Roquefort, to bodies elaborated by molds which develop in the cheese. In the highly flavored sorts some of the fatty acids of a very marked odor are present in abundance, as are also the ammonia-like bodies. Indeed, in eating such cheese as Camembert a trace of ammonia flavor may often be plainly detected.

The cleavage of the nitrogenous material of the cheese and other changes are brought about chiefly by the action of enzyms originally present in cheese or by microorganisms and are to be regarded as fermentative and not as putrefactive changes.

The liking for highly flavored cheeses of strong odor is a matter of individual preference, but from the chemist's standpoint there is no reason for the statement often made that such cheeses have undergone putrefactive decomposition.

COMPOSITION OF CHEESE AND SOME OTHER FOODS COMPARED.

In the present state of our knowledge concerning dietetics it seems best to give the housekeeper general rather than absolute rules with respect to the kind and amount of food which should be eaten at any meal or at any given time by persons in normal health living under usual conditions. It is not necessary, therefore, for the housekeeper to know the exact composition of food materials in order to cater well for her family, a rough approximation being sufficient for the purpose. In the case of cheese she will be near enough to the fact if she thinks of it as composed approximately of equal parts by weight of proteids, fats, and water. This rough conception is sufficient to associate it in her mind with the foods of high proteid value, a point which is important in connection with the making of bills of fare. It should lead her to class it also with the foods which are rich in fat and prevent her from combining it unnecessarily with other fatty foods.

In order, however, that the question of the use of cheese in the diet may be adequately discussed, knowledge of its composition in comparison with other foods is desirable, and there is an abundance of data available on this subject, since the composition of cheese and other foods has often been investigated at the Department of Agriculture, in experiment station laboratories, and in many other places where nutrition problems are studied. An extended summary of analyses of cheese of different sorts is included in an earlier publication of this department.[1]

Data regarding the composition of cheese and a few other common foods are summarized in the following table:

Average composition of cheese and some other common foods as purchased, and also on the basis of edible portion.

Food materials.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Cheese		34.2	25.2	33.7	2.4	3.8	1,950
Beef of average composition as purchased	18.6	50.5	15.2	15.5		.7	935
Edible portion		62.2	18.8	18.8		.9	1,145
Porterhouse steak as purchased	12.7	52.4	19.1	17.9		.8	1,110
Edible portion		60.0	21.9	20.4		1.0	1,270
Loin steak, broiled, edible portion		54.8	23.5	20.4		1.2	1,300
Dried beef		53.7	26.4	6.9		8.9	790
Eggs as purchased	11.2	65.5	13.1	9.3		.9	635
Edible portion		73.7	13.4	10.5		1.0	720
Milk		87.0	3.3	4.0	5.0	.7	310
Bread		35.3	9.2	1.3	53.1	1.1	1,215
Potatoes as purchased	20.0	62.6	1.8	.1	14.7	.8	295
Edible portion		78.3	2.2	.1	18.4	1.0	385
Apples as purchased	25.0	63.6	.3	.3	10.8	.3	190
Edible portion		84.6	.4	.5	14.2	.3	290

It will be seen from the above table that cheese has nearly twice as much protein, weight for weight, as beef of average composition as purchased and that its fuel value is more than twice as great. It contains over 25 per cent more protein than the same weight of porterhouse steak as purchased, and nearly twice as much fat.

As shown by the figures in the above table, cheese contains 3.8 per cent ash. Of this a considerable part may be salt added in cheese making. Like the milk from which it is made, cheese ash is characterized chiefly by the presence of calcium (lime), magnesium, phosphorus, and iron, the average values as given in earlier bulletins of the department[1] being 1.24 per cent calcium oxid, 0.049 per cent magnesium oxid, 1.49 per cent phosphorus pentoxid, and 0.0015 per cent iron.

---

[1] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 146.

The total amount of the mineral matter needed per day by the body is relatively small, yet mineral matter is very important. It is commonly assumed and is probably true, that a mixed diet reasonably varied and reasonably generous will supply all the ash constituent which the body requires. If for any reason calcium and phosphorus are lacking in the diet, the amounts may be readily increased (as pointed out in one of the publications just cited) by a free use of milk and such milk products as cheese and junket, without decreasing the palatability of the diet or materially increasing its cost.

NUTRITIVE VALUE AND COST OF CHEESE AND SOME OTHER FOOD MATERIALS.

Since the market prices of foods vary, it is difficult to compare the amounts of nourishment secured for a given sum, 10 cents say, in buying different food materials. We may, however, suppose that foods have certain prices and make the comparison on this basis. In the following table the amount of cheese obtained for 10 cents when cheese costs 22 cents a pound is shown, together with the protein and energy value of this quantity, this value being compared with similar values for a number of other common foods at certain assumed prices per pound.

Amounts of protein and energy obtained for 10 cents expended for cheese and other foods at certain assumed prices per pound.

Food materials.	Price.	10 cents will buy—	10 cents' worth will contain—	
			Proteid.	A fuel value of—
		Ounces.	*Ounces.*	*Calories.*
Cheese	22 cents per pound	7.3	1.9	886
Beef, average	20 cents per pound	8.0	1.2	467
Porterhouse steak	25 cents per pound	6.4	1.3	444
Dried beef	do	6.4	.1	315
Eggs	24 cents per dozen	10.0	1.3	198
Milk	9 cents per quart	38.3	1.2	736
Wheat bread	5 cents per pound	32.0	2.9	2,400
Potatoes	60 cents per bushel	160.0	....	2,950
Apples	1½ cents per pound	106.7	....	1,270

Since cheese is ready to be eaten when it comes from the market, it may be more interesting for some purposes to compare its composition with that of cooked beef, freed from bone and from superfluous fat, such a piece as would be served to a person at the table. Weight for weight, cheese has appreciably more protein than such cooked beef, and 50 per cent more fat.

---

[1] U. S. Dept. Agr., Office Expt. Stas. Buls. 185 and 227.

So far as its composition is concerned, then, cheese is entitled to be considered as directly comparable with meat. The possibilities of using cheese and some other food materials in the same way as meat is discussed in some detail in an earlier publication of this department.[1] It is so used by the peasants of some parts of Europe, and was formerly so used among many other groups of people. The fact that it is not more commonly so used in this country is probably due to several causes. One cause is habit, which makes the meal seem incomplete unless it includes meat; another is the fact that since cheese has a more pronounced flavor than meat, it is not so likely to be generally acceptable as the chief food of a meal. There is always likely to be at least one member of the family who does not relish it in quantity. Another cause is the fact that it is commonly believed to be indigestible, and still another is the fact that housekeepers, through lack of experience, are much less skillful in the arrangement of bills of fare in which cheese is the central food than they are in arranging bills of fare in which meat is thus used. These last two causes will be considered in sections which follow.

THE DIGESTIBILITY OF CHEESE.

As was stated above, cheese has been thought a cause of digestive disturbances, but work recently done by the Office of Experiment Stations, in cooperation with the Bureau of Animal Industry, and briefly summed up in a recent publication tends to disprove this.[2]

In the large number of experiments which were conducted, young men in good health were fed on a diet consisting of bread and fruit combined with American factory cheese which was made with different amounts of rennet and in different stages of ripening. The results showed that over 90 per cent of the nitrogeous material of the cheese was digested—that is, retained in the body—and nearly 90 per cent of the energy it supplied was available. In other words, cheese compares favorably with other foods in thoroughness of digestion—that is, in the percentage finally digested. Furthermore, it did not cause constipation or other physiological disturbances.

The above statement refers to full-cream cheese. Experiments made at the same time gave practically the same values for the digestibility of skim-milk cheese, of Swiss cheese, of Roquefort and Camembert cheese, and of cottage cheese.

Artificial digestion experiments made at the Minnesota Agricultural Experiment Station[3] indicate that cheese protein is digested by the ferments of the intestines rather than by those of the stomach, and this is suggested as a reason for its reputation as a "hearty" food, the belief being that some foods which remain in the stomach longer than the average time, or are not digested by the stomach, are "hearty." Cheese protein (casein) is intimately associated with fat, and there is experimental evidence to show that this condition has an effect upon the progress of digestion in the stomach.

---

[1] U. S. Dept. Agr., Yearbook 1907, p. 367.

[2] U. S. Dept. Agr., Bur. Anim. Indus. Circ. 166.

[3] Minnesota Sta. Bul. 74.

The burning sensation or similar sensations sometimes experienced after eating certain sorts of cheese has been attributed to the presence of small amounts of free fatty acids.[1] It is commonly said that cheese is difficult to digest, the idea being that the body expends more labor in assimilating it than is required for other comparable foods. Experiments recently carried on by the Office of Experiment Stations in which the respiration calorimeter was used to study the energy expenditure during the period of active digestion, do not indicate that cheese differs materially in ease of digestion from a comparable amount of meat.[2] Uncooked full-cream cheese was used in these experiments. Another series recently begun by the Office of Experiment Stations with cooked cheese, though not yet sufficiently advanced to be conclusive, indicates that cheese thus eaten does not differ materially from raw cheese in this respect.

In connection with the use of cooked cheese in the diet, one fact should always be kept in mind. This is that, in common with all other fatty foods, cheese which has been overheated in cooking is likely to contain burned—that is, decomposed—fats. Disturbances from this cause, however, should be laid to poor cooking and not to the composition of this special food.

The use of potassium bicarbonate has often been recommended for increasing the digestibility of cheese, the amount suggested being a level teaspoonful to a pound of cheese. That the bicarbonate renders the cheese soluble in any appreciable degree, as has been claimed, is not apparent from a number of experiments which have been made. It does, however, neutralize some of the free fatty acids of the cheese, thus destroying some of the characteristic flavor. To some people this may be an advantage, but to others it would be counted a disadvantage.

THE USE OF CHEESE IN THE DIET.

It has been the purpose, in preparing this discussion of cheese, to consider ways in which mild-flavored sorts may serve as staple articles of diet, rather than the use of highly flavored varieties as appetizers and as accompaniments of other foods. The use of highly flavored cheese as a condiment is customary and may profitably be extended, since it offers a simple way of adding to the attractiveness of the diet. The variety of the cheese selected is a matter of choice, some persons preferring such kinds as well-ripened American full-cream cheese or the potted cheeses, and others such sorts as Roquefort, Camembert, and other varieties. From the physiologist's standpoint, cheese used in this way for its flavor should really form a part of a well-balanced meal rather than be added to a meal which already supplies an abundance of nutritive material. In other words, condimental cheeses may better accompany a moderate than a very generous menu.

---

[1] Hutchison's "Food and the Principles of Dietetics," London, 1901, p. 145.

[2] U. S. Dept. Agr., An. Rpt. Sec. 1910, p. 149; Rpt. Office Expt. Stas. 1910, p. 35; Yearbook 1910, p. 359.

In considering the use of cheese in quantity as an integral part of the diet there are many possibilities from simple combinations like bread and cheese to elaborate dishes in which cheese is used as a flavor and as a principal constituent.

As has been pointed out, cheese, being rich in both protein and fat, would logically replace such foods as meat, fish, and eggs when taken in quantity, rather than cereal foods characterized by a large amount of starch, or succulent foods, such as vegetables and fruits. In planning menus of which cheese forms a large part the housekeeper should bear these facts in mind.

BILL-OF-FARE MAKING WITH CHEESE AS THE CENTRAL FOOD.

Since meat has so generally been the chief protein food of a meal, and the kind selected usually has determined the choice of vegetables and condiments, it is not strange that very many housekeepers should be inexperienced and consequently unskillful in planning meals in which cheese is substituted for meat when for any reason they may desire to make such a change. In seeking skill they might take a suggestion from the experiments to which reference has been made, and also from a case investigated and reported by the Office of Experiment Stations, of a man who lived for months upon a diet of bread, fruit, and cheese, and who remained in good health and active, and did not weary of the monotony of the diet.

The first two articles of the diet mentioned, namely, the bread and the cheese, could have been taken in such amounts as to constitute what is usually considered a balanced ration, i. e., in such amounts as to supply the right quantity of muscle-forming foods in comparison with the energy value. The bread and cheese taken with the fruit, however, make a ration which is well balanced not only in the older and more widely accepted sense, but also in the more modern sense that it makes an attractive and palatable combination of foods, as well as a balanced ration, and thus favors digestion. The watery and refreshing fruits or succulent vegetables with their large supply of cellulose are a pleasant contrast to the concentrated and fatty cheese.

Housekeepers would probably find that if in planning menus of which a cheese dish is the chief feature they were to take pains to supply also crisp, watery vegetables, water cress, celery, lettuce served with a dressing or with salt alone, or simple fruit salads, and would give preference to refreshing fruits, either fresh or cooked, rather than to what are known as heavy desserts, they would in general be more successful in pleasing those who are served.

There is another point also to be considered in combining cheese with other foods. Whether it is raw or cooked it is likely to be somewhat soft, and so seems to call for the harder kinds of bread—crusty rolls or biscuit, zweiback, toast, pulled bread, rye bread, the harder brown breads, or crackers, and some of the numerous crisp ready-to-eat cereal breakfast foods. Brittle cookies, too, seem more suitable than rich soft cakes or puddings for the dessert in such meals.

A few bills of fare are given below which experience has shown to represent combinations of dishes which are palatable and which, if eaten in usual amounts, will supply protein and energy in proportions which accord with usual dietary standards. Menus such as these are more commonly served at lunch or at supper, but they might equally well be served for dinner, the selection of dishes for any meal being of course chiefly a matter of custom and convenience for those who have any range of choice.

Suggested bills of fare in which cheese dishes are the chief source of protein and fat.

MENU No. 1.

Macaroni and cheese (p. 26 or p. 27).
Raisin bread or date bread.
Orange and water-cress salad.
Baked apples.
Sugar cookies.
Cocoa.

MENU No. 2.

Cheese fondue (p. 24 or p. 25).
Toast, zwieback, or thin and crisp baking-powder biscuit.
Celery.
Potatoes, baked, boiled, or fried in deep fat.
Peas, or some other fresh vegetables.

MENU No. 2—Continued.

Coffee.
Fruit salad with crisp cookies or meringues.

MENU No. 3.

Clear soup.
Baked eggs with cheese (p. 29) or Boston roast (p. 28).
Baked potatoes.
Lettuce salad.
A sweet jelly, crab apple or quince for example, or a preserve.
Rye bread.
Orange or banana shortcake.
Tea.

These bills of fare should be taken as suggestive merely and not as a solution of the problem. In fact, the whole art of making bills of fare needs developing. There is abundant evidence that overeating, where it exists, is frequently due to the fact that meals are not skillfully planned. People often continue eating after they have taken enough in total bulk because they have not had all they want of some particular kind of food. The meal has contained too large a percentage of proteid or too much starch; has been too moist or too dry; too highly flavored or not sufficiently flavored. Bill-of-fare making calls not only for knowledge of food values but also for skill in combining flavors and textures.

In this discussion of menu making, and of the use of cheese as an integral part of the diet, the aim has been to suggest ways of using cheese to add to the palatability of meals made up of usual dishes, and to suggest dishes containing cheese which could serve as substitutes for meat dishes when so desired, and also for dishes of many sorts to be used as taste suggests and in which the nutritive value as well as the flavor is increased by the addition of cheese. If cheese is used and in quantity, it is obvious that some other proteid and fat foods should be diminished, in order that the meal or day's menu may not be unduly hearty.

For the convenience of the housekeeper, a number of recipes for cheese dishes are given in later pages, these being preceded by directions for making cottage cheese and other similar cheeses which are usually made in the home.

HOMEMADE CHEESE.

Even as late as a generation or two ago cheese of different kinds was made at home for family use, as sour-milk or cottage cheese still is, and cheese making was very generally a farm industry, cheese, like butter, being sold by the farmer who made it. Cottage cheese is very commonly homemade. Most types of cheese, however, are now as a rule made on a large scale in factories where advantage may be taken of labor-saving devices. The general topic of farm cheese making has been considered in an earlier bulletin of this series,[1] prepared by the Dairy Division of the Bureau of Animal Industry.

Curds and Whey.

Cheese curds and whey, an old-fashioned dish, which is often spoken of in accounts of life in earlier times, sometimes refers to sour-milk curd and sometimes to curd separated with rennet. This dish when made with rennet is much like junket and though far less common to-day than was once the case is wholesome and palatable.

Cottage Cheese.

This cheese is very commonly prepared in the home, and the process of making it is very simple. It consists merely of curdling the milk, separating the curd from the whey, seasoning, and pressing it.

The curd is formed by the souring of the milk, and the process is hastened if the milk is kept warm, the best temperature being about blood heat, 96° F. A temperature much above this should be avoided, as the curd is likely to become hard and tough if much heated. The danger is usually not that the whole will be overheated but that the portion nearest the fire will be. In the old-fashioned kitchen there was usually a place where the milk could stand till it was uniformly warm throughout. With our present cooking arrangements it is often desirable to hasten the process. This may be done by setting the milk into a pan of warm water or by pouring hot water directly into the milk itself. The effect of the latter method is to remove much more of the acid than when the whey is left undiluted. Some consider this a great advantage.

---

[1] U. S. Dept. Agr., Farmer's Bul. 166.

If, for any reason, the curd is overheated, it should be put through a meat chopper. This will insure cottage cheese of excellent texture.

If the milk is thoroughly chilled before the whey is drained off it retains more of the fat than if this is done when warm. Under no circumstances, however, is much of the fat retained in cottage cheese. It is therefore more economical to make it out of skim milk and to add the fat to the curd in the form of butter or cream.

Chopped parsley, caraway seeds, chopped olives, and pimiento may all be used for flavoring if such flavored cheese is preferred to plain cottage cheese.

Cottage cheese [1] is most commonly consumed immediately, but if made in quantity for commercial purposes, it may be packed in tubs and placed in cold storage. Sometimes it is formed into rolls or blocks and wrapped in tinfoil when marketed. Such cheese is used without ripening.

Though cottage cheese is usually made by allowing the milk to sour naturally, it is sometimes more convenient to curdle the milk by adding rennet, and some housekeepers have a preference for cottage cheese thus made, since the flavor is milder and the acid taste which it possesses when made from sour milk is lacking.

Sour-Cream Cheese.

When cream is to be made into cheese similar to cottage cheese, it should be drained without having previously been heated. The drainage is facilitated by moistening the cloth in salt water before the cream is poured in. The curd is formed either by souring or by the addition of rennet.

Uncooked Curd, or French Cottage Cheese.

The French make cheese from sour milk without heating it. They pour the milk into earthen molds which have holes in the bottom. A very fine sieve may be used instead of the molds. The whey drips out and the curd assumes a custardlike consistency and takes the shape of the mold. When sufficiently stiff, the cheese is chilled, and is eaten with sweet cream and sugar. It is a staple dessert in many French families, especially in hot weather, and is delicious served with acid fruit, such as currants, or with strawberries.

Junket.

If cottage cheese is made from sweet milk and rennet and served without breaking and separating the curd and whey, the dish is called junket. It is customary to season it a little, as with grated nutmeg or with cinnamon and sugar.

Buttermilk Cheese.

At the Wisconsin Experiment Station [2] a method has been devised for making a soft moist cheese out of buttermilk. When made on a large scale, as it might be in creameries, there are various precautions to be taken which are pointed out in the publication cited. In making it in small quantities, these precautions are unnecessary, and the method is even simpler than that of making cottage cheese, because the quality does not depend so much on the temperature.

---

[1] North Carolina Sta. Bul. 210.

[2] Wisconsin Sta. Bul. 195.

To make the buttermilk cheese, heat buttermilk gradually to about 130° or 140° F. Allow it to cool and strain it. As the curd will settle to the bottom, most of the whey may be poured off before the draining is begun.

This cheese is, of course, almost wholly without fat and yet, probably because the particles of curd are very finely divided, it has a smooth consistency, which suggests the presence of fat. It may be served seasoned with salt only or it may be mixed with butter or cream and seasonings. It is suitable for combining with olives and pimientos, as recommended on page 34, or for any use to which the ordinary cream cheeses are put.

Buttermilk Cream.

This product also was devised by the Wisconsin Experiment Station.[1] By controlling the temperature in heating the buttermilk and not allowing it to go above 100° F., a compound is made which after draining has the consistency of a very thick cream. It is claimed by the station investigators that this "cream" is suitable for eating on bread in place of butter.

The recipes on pages 34 and 35 suggest ways of making a salad dressing out of buttermilk cream.

Devonshire Cream.

Devonshire cream somewhat resembles sweet cream in flavor and consistency. It is very much liked in England, where it is commonly eaten with fresh or preserved fruit, but is not so well known in America.

To make Devonshire cream, allow a pan of whole milk to stand for 24 hours in a cool place or for 12 hours in a warmer place. Place the pan on the cooler part of the stove and heat until the milk is very hot, but not to the boiling point. If heated too much a thick skin will form on the surface. The more slowly the milk is heated the better. Having been heated, the milk should be kept in a cool place for 24 hours and then skimmed. The thick cream obtained has a characteristic flavor and texture.

CHEESE DISHES AND THEIR PREPARATION.

The list of cheese dishes in the culinary literature of this and other countries is a long one, but most of them are variations of a comparatively small number of general types. Those which have been selected and studied experimentally represent the principal types and in many cases have been adapted to American methods of preparations and tastes. In some instances, this has resulted in new and perhaps more rational combinations than those which served as models.

For convenience, the cheese dishes included in this bulletin have been grouped under the following heads:

(1) Cheese dishes which may serve as meat substitutes.
(2) Cheese soups and vegetables cooked with cheese.
(3) Cheese salads, sandwiches, and similar dishes.
(4) Cheese pastry, cheese sweets, and similar dishes.

Variety may be obtained in the recipes by varying the flavorings. Among the best flavorings for cheese dishes are onion, chives, and the ordinary green sweet pepper. Since the cheese needs very little cooking, however, and onion or the pepper needs a great deal, they should always be previously cooked, either by stewing in a very little water, or by cooking in butter. The seeds of the pepper, of course, should be removed before cooking. Where chopped celery is used, as it may be in most of these dishes, it, too, should be cooked beforehand until tender. Other good flavors are mustard, curry powder, onion juice, chopped olives, pimiento, and, according to European recipes, nutmeg or mace.

---

[1] Loc. cit.

In preparing the cheese it often has been found convenient to use a very coarse grater having slits instead of the usual rounded holes. Such a grater, in spite of its name, shaves the cheese instead of grating it. When the cheese is soft this is an advantage, since the grater does not become clogged.

CHEESE DISHES WHICH MAY BE USED IN THE SAME WAY AS MEAT.

Meat is wholesome and relished by most persons, yet it is not essential to a well-balanced meal and there are many housekeepers who for one reason or another are interested in lessening the amount of meat which they provide or to substitute some other foods for it. The problem with the average family is undoubtedly more often the occasional substitution of other palatable dishes for the sake of variety, for reasons of economy, or for some other reason than the general replacement of meat dishes by other things.

Foods which are to be served in place of meat should be rich in protein and fat and should also be savory. Cheese naturally suggests itself as a substitute for meat, since it is rich in the same kinds of nutrients which meat supplies, is a staple food with which everyone is familiar, and is one which can be used in a great variety of ways. In substituting cheese for meat, especial pains should be taken to serve dishes which are relished by the members of the family. A number of recipes for dishes which contain cheese are given below. They are preceded by several recipes for cheese sauces which, as will appear, are called for in the preparation of some of the more substantial dishes.

Cheese Sauce No. 1.

1 cupful of milk.
2 tablespoonfuls of flour.
1 ounce of cheese (¼ cupful of grated cheese).
Salt and pepper.

Thicken the milk with the flour and just before serving add the cheese, stirring until it is melted.

This sauce is suitable to use in preparing creamed eggs, or to pour over toast, making a dish corresponding to ordinary milk toast, except for the presence of cheese. It may be seasoned with a little curry powder and poured over hard-boiled eggs.

Cheese Sauce No. 2.

Same as cheese sauce No. 1, except that the cheese is increased from 1 to 2 ounces. This sauce is suitable for using with macaroni or rice, or for baking with crackers soaked in milk. (See p. 27.)

Cheese Sauce No. 3.

Same as cheese sauce No. 1, except that two cupfuls of grated cheese or 8 ounces are used. This may be used upon toast as a substitute for Welsh rabbit.

Cheese Sauce No. 4.

Same as cheese sauce No. 2, save that 2 tablespoonfuls of melted butter are mixed with the flour before the latter is put into the milk. This sauce is therefore very rich in fat and has only a mild flavor of cheese.

Among the recipes for dishes which may be used like meat, the first 30 are such that, eaten in usual quantities, they will provide much the same kind and amount of nutritive material as the ordinary servings of meat dishes used at dinner. In several cases there is a resemblance in appearance and flavor to common meat dishes, which would doubtless be a point in their favor with many families.

While, chiefly owing to custom, it may not accord with the taste of the family to serve cheese dishes at dinner in place of meat, it is much more in accord with usual dietary habits in American homes to serve such dishes at least occasionally for lunch, for supper, or for breakfast; that is, for a less formal meal than dinner. The last group of recipes in this section, beginning with "breakfast cereals with cheese," supply rather smaller proportions of nutritive materials than those in the first group and so may be more suitable for use at the less hearty meals. There is no hard and fast line to be drawn between the two groups, however, and many of the recipes may be used interchangeably.

In the recipes calling for large amounts of cheese the food value is given, not in figures, but in comparison with beef of average composition and average percentage of waste. This comparison is necessarily rough owing to the varying composition of the foods and the varying weights of such ingredients as a cupful of grated cheese or bread crumbs. In making the comparisons, beef of average composition has been considered to have 15.2 per cent of protein, and a fuel value of 935 calories per pound; ordinary American cheese has been considered to have 26 per cent of protein and a fuel value of 1,965 calories per pound. After many weighings, 4 ounces was decided to be the average weight of a cupful of cheese and 2½ ounces the average weight of a cupful of bread crumbs. These weights have been taken, therefore, in calculating the food value of dishes. When cheese is very soft, however, it may be pressed into a cup and measured like butter. Under these circumstances, the weight of a cupful of cheese may be considered one-half a pound. The price of cheese is taken as 22 cents a pound, of butter 25 cents a pound, of eggs 25 cents a dozen, in this and all similar calculations in this bulletin. Prices vary with time, place, and season. Those mentioned above are such as were paid for materials at the time the experiments here summarized were made and are not extreme values in either direction. Like all such estimates, the calculations are only relative, and the housekeeper who wishes to estimate the comparative cost of the cheese dishes and other foods can readily do so by taking into account the amount of materials used and the prices paid for ingredients at any particular time.

Cheese Fondue No 1.

1⅓ cupfuls of soft, stale bread crumbs.
6 ounces of cheese (1½ cupfuls of grated cheese or 1⅓ cupfuls of cheese grated fine or cut into small pieces.)
4 eggs.
1 cupful of hot water.
½ teaspoonful of salt.

Mix the water, bread crumbs, salt, and cheese; add the yolks thoroughly beaten; into this mixture cut and fold the whites of eggs beaten until stiff. Pour into a buttered baking dish and cook 30 minutes in a moderate oven. Serve at once.

The food value of this dish, made with the above quantities, is almost exactly the same as that of a pound of beef of average composition and a pound of potatoes combined. It contains about 80 grams of proteids and has a fuel value of about 1,300 calories. Estimated cost, 18 cents, calculated as explained on p. 23.

Cheese Fondue No. 2.

1⅓ cupfuls of hot milk.
1⅓ cupfuls of soft, stale bread crumbs.
1 tablespoonful of butter.
4 eggs.
⅓ of a pound of cheese (1⅓ cupfuls of grated cheese or 1 cupful of cheese cut into small pieces).
½ teaspoonful of salt.

Prepare as in previous recipe.

The protein value of this dish is equal to that of 1⅓ pounds of potato and beef, the fuel value, however, being much in excess of these. Calculated cost (see p. 23), 22 cents.

In making either of these fondues, rice or other cereals may be substituted for bread crumbs. One-fourth cupful of rice measured before cooking, or one cupful of cooked rice or other cereals, should be used.

A comparison of the recipes for the two fondues may indicate the general principle on which the recipes in this bulletin have been worked out. The second recipe is one commonly found in cookbooks. In the first one, the butter has been omitted and water substituted for milk and the amount of cheese is slightly increased. This makes a somewhat cheaper dish and one which is less rich because its percentage of fat is not so great. For this reason it is easier to adjust to the ordinary bill of fare. A dish in which there is combined cheese with its large percentage of fat, butter with its 85 per cent of fat, and eggs with their 10 per cent of fat, is too rich to admit of being combined rationally with other fatty dishes. It therefore limits the number of dishes that may be served with it, making milk soup, for example, or dishes containing white sauce or those containing much butter or oil seem out of place. The omission of butter from the ordinary recipes and the substitution of water or skimmed milk for whole milk may perhaps be the means of making cheese dishes more wholesome and more generally acceptable.

Another advantage of omitting butter from cheese dishes and of substituting water or skimmed milk for whole milk is that it makes it possible to increase the amount of cheese without making the dish too rich. This is of advantage to those who like the flavor of cheese, and also, because it tends to increase the tissue-forming value of the dish, particularly if skimmed milk is used rather than water.

Boiled Fondue.

1½ cupfuls of bread crumbs.
1½ cupfuls of milk.
1½ cupfuls of cheese cut into small pieces.
1 egg.
2 tablespoonfuls of butter.
6 ounces of crackers.

Soak the bread in the milk. Melt the butter and add the cheese. When the cheese has melted add the soaked crumbs, the eggs slightly beaten, and the seasoning. Cook a short time and serve on toasted crackers.

Since it consists of essentially the same ingredients, the food value of this dish is obviously much the same as that of fondue made in other ways.

Rice Fondue.

1 cupful of boiled rice.
2 tablespoonfuls of milk.
4 eggs.
1 cupful of grated cheese.
½ teaspoonful of salt.
1 teaspoonful of some commercial meat sauce, or similar flavoring.

Heat the rice in the milk, add the other ingredients, and cook slowly until the cheese is melted. Serve on crackers or toast.

The food value is not far from that of a pound of beef of average composition, and the calculated cost (see p. 23) is 15 cents.

Corn and Cheese Souffle.

1 tablespoonful of butter.
1 tablespoonful of chopped green pepper.
¼ cupful of flour.
2 cupfuls of milk.
1 cupful of chopped corn.
1 cupful of grated cheese.
3 eggs.
½ teaspoonful of salt.

Melt the butter and cook the pepper thoroughly in it. Make a sauce out of the flour, milk, and cheese (see p. 23); add the corn, cheese, yolks, and seasoning; cut and fold in the whites beaten stiffly; turn into a buttered baking dish and bake in a moderate oven 30 minutes.

Made with skimmed milk and without butter, this dish has a food value slightly in excess of a pound of beef and a pound of potatoes. Calculated cost (see p. 23), about 20 cents.

Welsh Rabbit.

1 tablespoonful of butter.
1 teaspoonful of cornstarch.
½ cupful of milk.
½ pound of cheese, cut into small pieces.
¼ teaspoonful each of salt and mustard.
A speck of cayenne pepper.

Cook the cornstarch in the butter; then add the milk gradually and cook two minutes; add the cheese and stir until it is melted. Season and serve on crackers or bread toasted on one side, the rabbit being poured over the untoasted side. Food value is that of about three-fourths of a pound of beef. Calculated cost (see p. 23), 13 cents.

Tomato Rabbit.

2 tablespoonfuls of butter.
2 tablespoonfuls of flour.
¾ cupful of milk.
¾ cupful of stewed and strained tomatoes.
⅛ teaspoonful of soda.
1 pound of cheese.
2 eggs, slightly beaten.
Salt, mustard, cayenne pepper.

Cook the butter and the flour together, add the milk, and as soon as the mixture thickens add tomatoes and soda. Then add cheese, eggs, and seasoning. Serve on toasted whole wheat or Graham bread.

Green Corn, Tomato, and Cheese.

1 tablespoonful of butter.
2 cups of grated cheese.
¾ cup of canned or grated fresh corn.
1 ripe pimiento.
½ cup of tomato purée.
2 egg yolks.
1 teaspoonful of salt.
½ teaspoonful of paprika.
1 clove of garlic.
4 slices of bread.

Into the melted butter stir the cheese until it, too, is melted. Then add the corn and pimiento, stir for a moment and add the egg yolks beaten and mixed with the tomato juice and the salt and paprika. Have ready the bread toasted on one side and very lightly rubbed on its untoasted side with the garlic cut in two. Pour the mixture over the untoasted side of the bread and serve at once. A poached egg is sometimes placed on top of each portion, making a very nutritious combination.

Macaroni and Cheese No. 1.

1 cupful of macaroni, broken into small pieces.
2 quarts of boiling salted water.
1 cupful of milk.
2 tablespoonfuls of flour.
¼ to ½ pound of cheese.
½ teaspoonful of salt.
Speck of cayenne pepper.

Cook the macaroni in the boiling salted water, drain in a strainer, and pour cold water over it to prevent the pieces from adhering to each other. Make a sauce out of the flour, milk, and cheese. (See p. 23.) Put the sauce and macaroni in alternate layers in a buttered baking dish, cover with buttered crumbs, and heat in oven until crumbs are brown.

Macaroni and Cheese No. 2.

A good way to prepare macaroni and cheese is to make a rich cheese sauce and heat the macaroni in it. (See p. 23.) The mixture is usually covered with buttered crumbs and browned in the oven. The advantage of this way of preparing the dish, however, is that it is unnecessary to have a hot oven, as the sauce and macaroni may be reheated on the top of the stove.

Macaroni with Cheese and Tomato Sauce.

Boiled macaroni may be heated in tomato sauce and sprinkled with grated cheese just before serving.

Italian Macaroni and Cheese.

1 cupful of macaroni broken into small pieces.
2 quarts of boiling salted water.
½ onion.
2 cloves.
1½ cupfuls of tomato sauce.
½ cupful or more of grated cheese.

Cook the macaroni in the boiling salted water with the onion and cloves. Drain, remove the onion and cloves, reheat in tomato sauce, and serve with grated cheese.

Cheese and Macaroni Loaf.

½ cupful of macaroni broken into small pieces.
1 cupful of milk.
1 cupful of soft bread crumbs.
1 tablespoonful of butter.
1 tablespoonful of chopped green pepper.
1 teaspoonful each of chopped onion and parsley.
3 eggs.
1 teaspoonful of salt.
½ cupful of grated cheese.

Cook the macaroni in boiling salted water until tender, and rinse in cold water. Cook the parsley, onion, and pepper in a little water with the butter. Pour off the water or allow it to boil away. Beat the egg white and yolk separately. Mix all the ingredients, cutting and folding in the stiffly beaten whites at the last. Line a quart baking dish with buttered paper; turn the mixture into it; set the baking dish in a pan of hot water, and bake in a moderate oven from one-half to three-fourths of an hour. Serve with tomato sauce.

Baked Rice and Cheese No. 1.

1 cupful of uncooked rice and
4 cupfuls of milk;
or,
3 cupfuls of cooked rice and
1 cupful of milk.
2 tablespoonfuls of flour.
½ pound of cheese.
½ teaspoonful of salt.

If uncooked rice is used, it should be cooked in 3 cupfuls of milk. Make a sauce with one cupful of milk, add the flour, cheese, and salt. (See p. 23.) Into a buttered baking dish put alternate layers of the cooked rice and the sauce. Cover with buttered crumbs and bake until the crumbs are brown. The proteids in this dish, made with rice cooked in milk, are equal to those of nearly 1¾ pounds of average beef. If skimmed milk is used, the fuel value is equal to nearly 3½ pounds of beef. Whole milk raises the fuel value still higher. Estimated cost (see p. 23), 28 cents.

Baked Rice and Cheese No. 2.

¼ pound of cheese grated or cut into small pieces.
1 cupful of rice.
Milk as needed.

Cook the rice; put into a buttered baking dish alternate layers of rice and cheese; pour over them enough milk to come halfway to the top of the rice; cover with buttered crumbs and brown.

If the rice is cooked in milk either whole or skimmed, and one cup of milk is used to pour over it, this dish has as much protein as 1¼ pounds of beef of average composition, and a much higher fuel value.

Baked Crackers and Cheese No. 1.

9 or 10 butter crackers or Boston crackers.
¼ pound of cheese or 1 cupful of grated cheese.
1½ cupfuls of milk.
¼ teaspoonful of salt.
Flour.

Split the crackers, if the thick sort are selected, or with a sharp knife cut them into pieces of uniform size. Pour the milk over them and drain it off at once. With the milk, flour, cheese, and salt, make a sauce. (See p. 23.) Into a buttered baking dish put alternate layers of the soaked crackers and sauce. Cover with bread crumbs and brown in the oven, or simply reheat without covering with crumbs.

The above is a very satisfactory substitute for macaroni and cheese, and can be prepared in less time.

Baked Crackers and Cheese No. 2.

9 or 10 butter crackers or soda crackers.
2 cupfuls of hot milk, whole or skimmed.
1 cupful of grated cheese.
¼ teaspoonful of salt.

This is more quickly prepared than the preceding recipe, but as the milk is likely to curdle, it has not so good a consistency.

Soak the crackers in the milk; place them in a buttered baking dish in alternate layers with the cheese; pour the remaining milk over them and bake. This dish may be covered with buttered crumbs. Variety may be secured, in either this recipe or the preceding one, by putting a very small amount of mixed mustard on each cracker.

Cheese Rolls.

A large variety of rolls may be made by combining legumes, either beans of various kinds, cowpeas, lentils, or peas, with cheese of various kinds, and adding bread crumbs to make the mixture thick enough to form into a roll. Beans are usually mashed, but peas or small Lima beans may be combined whole with bread crumbs and grated cheese, and enough of the liquor in which the vegetables have been cooked may be added to get the right consistency. Or, instead of beans or peas, chopped spinach, beet tops, or head lettuce may be used. Homemade cottage cheese, and the soft cream cheese of commerce, standard cheese, or English dairy may be used.

Boston Roast.

1 pound can of kidney beans or equivalent quantity of cooked beans.
½ pound of grated cheese.
Bread crumbs.
Salt.

Mash the beans or put them through a meat grinder. Add the cheese and sufficient bread crumbs to make the mixture stiff enough to be formed into a roll. Bake in a moderate oven, basting occasionally with butter and water. Serve with tomato sauce. This dish may be flavored with onions, chopped and cooked in butter and water.

Pimiento and Cheese Roast.

2 cupfuls of cooked Lima beans.
¼ pound of cream cheese, commercial or homemade.
3 canned pimientos chopped.
Bread crumbs.

Put the first three ingredients through a meat chopper. Mix thoroughly and add bread crumbs until it is stiff enough to form into a roll. Brown in the oven, basting occasionally with butter and water.

Nut and Cheese Roast.

1 cupful of grated cheese.
1 cupful of chopped English walnuts.
1 cupful of bread crumbs.
2 tablespoonfuls of chopped onion.
1 tablespoonful of butter.
Juice of half a lemon.
Salt and pepper.

Cook the onion in the butter and a little water until it is tender. Mix the other ingredients and moisten with water, using the water in which the onion has been cooked. Pour into a shallow baking dish and brown in the oven.

Cheese and Spinach Roll.

2 quarts of spinach.
1 cupful of grated cheese.
1 tablespoonful of butter.
Salt.
Bread crumbs.

Cook the spinach in water for 10 minutes. Drain off the water, add the butter, cook until tender, and chop. Add the cheese and the eggs, and bread crumbs enough to make a mixture sufficiently stiff to form into a roll, or leave more moist and cook in a baking dish.

Vegetable and Cheese Rolls.

For the spinach of the above recipe there may be substituted beet tops, Swiss chard, or the outer leaves of lettuce.

Cheese Used in the Stuffing of Meat.

The mixtures in the preceding two recipes may be used for stuffing veal or beef. Eggs may be added if desired, and chopped onions or parsley may be cooked with the greens. In Italy roasts thus prepared are sprinkled with a little finely chopped garlic, and covered with celery tops and thin slices of bacon or fat pork before roasting.

Creamed Cheese and Eggs.

3 hard-boiled eggs.
1 tablespoonful of flour.
1 cupful of milk.
½ teaspoonful of salt.
Speck of cayenne.
¼ cupful or 1 ounce grated cheese.
4 slices of toast.

Make a thin white sauce with the flour and milk and seasonings. Add the cheese and stir until melted. Chop the whites and add them to the sauce. Pour the sauce over the toast, force the yolks through a potato ricer or strainer, sprinkle over the toast.

Baked Eggs with Cheese.

4 eggs.
1 cupful, or 4 ounces, of grated cheese.
1 cupful of fine, soft, stale bread crumbs.
¼ teaspoonful salt.
A few grains of Cayenne pepper.

Break the eggs into a buttered baking dish or into ramekins and cook them in a hot oven until they begin to turn white around the edge. Cover with the mixture of crumbs, cheese, and seasonings. Brown in a very hot oven. In preparing this dish it is essential that the oven be very hot or the egg will be too much cooked by the time the cheese is brown. To avoid this, some cooks cover the eggs with white sauce before adding crumbs.

The food value of the dish is very close to that of a pound of beef of average composition. The estimated cost (see p. 23) is about 14 cents.

For those who are particularly fond of cheese the amount of cheese in this recipe may be very much increased, thus making a much more nourishing dish. Or the amount may be reduced so as to give hardly more than a suggestion of the flavor of cheese.

Scrambled Eggs with Cheese.

½ pound of cheese grated or cut into small pieces.
8 eggs.
1 tablespoonful of chopped parsley.
A pinch of nutmeg.
½ teaspoonful of salt.

Beat the eggs slightly, mix them with the other ingredients, and cook over a very slow fire, stirring constantly, so that the cheese may be melted by the time the eggs are cooked. In food value the dish is equal to nearly 2 pounds of average beef. The calculated cost (see p. 23) is about 30 cents.

Swiss Eggs.

4 eggs.
½ cupful of cream.
1 tablespoonful of butter.
Salt and pepper.
¼ cupful of grated cheese.

Heat the butter and cream together, break in the eggs whole, sprinkle with salt and pepper. When nearly done, add the cheese. Serve on buttered toast. Strain the cream over the toast.

Cheese Omelet No. 1.

Cheese may be introduced into omelets in several ways. An ordinary omelet may be served with thin cheese sauce made in the following proportions:

1½ tablespoonfuls of flour.
¼ cupful of grated cheese.
1 cupful of milk.

This sauce may also be added to omelets in which boiled rice, minced meat, or some other nutritious material has been included.

Cheese Omelet No. 2.

Grated cheese may be sprinkled over an ordinary omelet before it is served.

Cheese Omelet No. 3.

Yolks of 2 eggs.
2 tablespoonfuls of hot water.
1 cupful of grated cheese.
Salt and pepper.
Whites of 4 eggs.
1 tablespoonful of butter.

Beat the yolks until lemon colored and add the hot water and the seasoning. Beat the whites until they are stiff, and add the cheese. Cut and fold the two mixtures together. Heat the butter in omelet pan and cook the mixture very slowly until it is brown on the underside. If possible, cook the top of the omelet in the oven or by means of a hot plate held over it.

Breakfast Cereals with Cheese.

That cheese combined with cereal foods makes a rational dish as regards the proportion of nutrients it supplies has been pointed out on another page (p. 18). Cheese and some of the crisp "ready to serve" cereal breakfast foods is a combination which is common, the cheese being melted with the cereal food, or simply served with it.

There are many who relish a piece of cheese with the cooked cereal so commonly eaten for breakfast and find such a combination satisfying to appetite and taste. Oatmeal or some other home-cooked breakfast cereal prepared with cheese is palatable, and such dishes have an advantage in that they may be served without cream and sugar. Since such a dish contains considerably more protein than the breakfast cereals as ordinarily served, it has a further advantage in that it may well serve as the principal item of a breakfast menu, instead of a preliminary to other courses. Such a combination as cereals cooked with cheese, toast, fruit, and tea, coffee, or chocolate, makes a palatable as well as nutritious breakfast and one which does not require much work to prepare and to clear away. A recipe for preparing oatmeal with cheese follows. Wheat breakfast foods, either parched or unparched, corn meal, and hominy may be prepared in the same way.

Oatmeal with Cheese.

2 cupfuls of oatmeal.
1 cupful of grated cheese.
1 tablespoonful of butter.
1 level teaspoonful of salt.

Cook the oatmeal as usual. Shortly before serving, stir in the butter and add the cheese, and stir until the cheese is melted and thoroughly blended with the cereal.

The cheese should be mild in flavor and soft in texture. The proportion of cheese used may be increased if a more pronounced cheese flavor is desired.

Cheese with Mush.

Cheese may be added to corn-meal mush or to mush made from any of the corn or wheat preparations now on the market. The addition of cheese to corn-meal mush is particularly desirable when the mush is to be fried.

Fried Bread with Cheese No. 1.

6 slices of bread.
1 cupful of milk.
2 ounces of cheese, or ½ cupful of grated cheese.
½ teaspoonful of salt.
½ teaspoonful of potassium bicarbonate.
Butter or other fat for frying.

Scald the milk with the potassium bicarbonate; add the grated cheese, and stir until it dissolves. Dip the bread in this mixture and fry it in the butter. The potassium bicarbonate helps to keep the cheese in solution. It is desirable, however, to keep the milk hot while the bread is being dipped.

Fried Bread with Cheese No. 2.

Cut stale bread into thin pieces. Put two pieces together with grated cheese between them; dip into a mixture of egg and milk and fry in butter or other fat.

Roman Gnocchi.

¼ cupful of butter.
¼ cupful of flour.
¼ cupful of cornstarch.
2 cupfuls of milk.
2 egg yolks.
¾ cupful of grated cheese.
Salt.

Melt the butter; cook the cornstarch thoroughly, and then the flour in the butter; add the milk gradually; cook three minutes, stirring constantly; add the yolks and one-half cupful of the cheese. Pour into a buttered shallow pan and cool. Cut into squares; place them on a platter a little distance apart; sprinkle with remaining cheese, and brown in the oven.

The proteid value is that of three-fourths of a pound of average beef, the fuel value that of 1¾ pounds. Calculated cost (see p. 23), 17 cents.

Cheese Soufflé.

2 tablespoonfuls of butter.
3 tablespoonfuls of flour.
½ cupful of milk (scalded).
½ teaspoonful of salt.
A speck of cayenne.
¼ cupful of grated cheese.
3 eggs.

Melt the butter; add the flour and, when well mixed, add gradually the scalded milk. Then add salt, cayenne, and cheese. Remove from the fire and add the yolks of the eggs, beaten until lemon colored. Cool the mixture and fold into it the whites of the eggs, beaten until stiff. Pour into a buttered baking dish and cook 20 minutes in a slow oven. Serve at once.

The proteid of this recipe is equal to that of half a pound of beef; the fuel value is equal to that of three-fourths of a pound.

Cheese Soufflé with Pastry.

2 eggs.
⅔ cupful of thin cream.
1 cupful of grated cheese.
½ cupful of Swiss cheese cut into small pieces.
Salt, cayenne pepper, and nutmeg.

Add the eggs to the cream and beat slightly, then add the cheese and seasoning. Bake 15 minutes in a hot oven, in patty tins lined with puff paste.

Cheese Croquettes.

3 tablespoonfuls of butter.
¼ cupful of flour.
¾ cupful of milk.
Yolks of 2 eggs.
1 cupful of cheese cut in very small pieces.
½ cupful grated cheese.
Salt and pepper.

Make with a white sauce, using the butter, flour, and the milk. Add the unbeaten yolks and stir until well mixed, then add the grated cheese. As soon as the cheese melts, remove from the fire, fold in the pieces of cheese, and add the seasoning. Spread in a shallow pan and cool. Cut into squares or strips, cover with an egg and crumb mixture, and fry in deep fat.

Fried Cheese Balls.

1½ cupfuls of grated cheese.
1 tablespoonful of flour.
The whites of 3 eggs.
Salt, pepper, cracker dust.

Beat the whites of the eggs; add the other ingredients; make into balls and roll in cracker dust. If the amount of flour is doubled, the mixture may be dropped from a spoon and fried without being rolled in crumbs.

CHEESE SOUPS AND VEGETABLES COOKED WITH CHEESE.

In these dishes the cheese is used not only to add nutritive value, but also to give its characteristic flavor either to materials otherwise rather mild in taste (as in potatoes with cheese) or to combine its flavor with that of some more highly flavored vegetables (as in cheese and vegetable soup). The ingenious housekeeper whose family is fond of cheese can doubtless think of many desirable ways of making such combinations besides those given in the following recipes:

Milk and Cheese Soup.

3 cupfuls of milk, or part milk and part stock.
1½ tablespoonfuls of flour.
1 cupful of grated cheese.
Salt and paprika.

Thicken the milk with the flour, cooking thoroughly. This is best done in a double boiler, with frequent stirrings. When ready to serve, add the cheese and the seasoning.

The proteids in this soup are equal in amount to those in five-sixths of a pound of beef of average composition; its fuel value is higher than that of a pound of beef.

Cheese and Vegetable Soup.

2 cupfuls of stock.
2 tablespoonfuls of finely chopped carrots.
1 tablespoonful of chopped onion.
A very little mace.
2 tablespoonfuls of butter.
2 tablespoonfuls of flour.
1½ teaspoonfuls of salt.
1 cupful of scalded milk.
¼ cupful of grated cheese.

Cook the vegetables a short time in one-half of the butter, add the stock and the mace, boiling 15 or 20 minutes. Strain and add the milk. Thicken with flour cooked in the remaining butter. Just before serving, stir in the cheese and cook until it is melted.

Scalloped Potatoes with Cheese No. 1.

Put into a buttered baking dish alternate layers of cheese sauce No. 1 (see p. 22) and cold boiled potatoes, sliced or cut into dice. Cover with buttered crumbs and bake.

Scalloped Potatoes with Cheese No. 2.

Put into a buttered baking dish alternate layers of white sauce and cold boiled potatoes, either sliced or cut into dice. Put over the top a layer of grated cheese and then a layer of buttered bread crumbs. Brown in the oven.

Scalloped Cabbage or Cauliflower with Cheese.

Cauliflower or cabbage may be scalloped according to either of the recipes given for scalloped potatoes and cheese. Sometimes a cauliflower is boiled whole, spread with grated cheese, then with buttered bread crumbs. It is browned in the oven and served with white sauce poured around it.

Cheese with Potato Puffs.

1 cupful of mashed potatoes.
¼ cupful of milk.
1 egg.
½ teaspoonful of salt.
½ cupful of grated cheese.

Beat the potatoes and milk together until thoroughly mixed. Add the egg and the salt and beat thoroughly. Finally add the cheese. Bake in muffin tins in a slow oven 10 or 15 minutes.

A similar dish may be made by scooping out the inside of a baked potato and mixing it with cheese as above. Fill the potato-skin shell with the mixture, return to the oven, and bake until light brown.

Potatoes with Cheese Sauce.

Cut boiled potatoes into cubes and serve with cheese sauce No. 1. (See p. 22.) This is one of the cheese and vegetable dishes most frequently found on restaurant menus.

CHEESE SALADS, SANDWICHES, AND SIMILAR CHEESE DISHES.

Cheese of one sort or another is a very common accompaniment of salads, and the combination is rational as well as palatable, for the constituents of the succulent foods—chiefly water and cellulose—supplement the protein and fat of the cheese. Cheese is often used also as a part of the salad.

A number of recipes are given below for cheese salads and other cheese dishes which may be served with dinner or other regular meals, or served as part of a special lunch or special supper. Many of the cheese dishes discussed in other sections are also commonly used for such occasions when something savory is desired which can be easily and quickly prepared.

Cheese with Salads.

Cheese or cheese dishes are an acceptable addition to salads. Neufchâtel or other cream cheese, either plain or mixed with pimientos and olives, may be passed with lettuce or may be cut into slices and served on lettuce.

Cheese balls are often served with salad. They are made of some soft cream cheese, and are frequently combined with chopped chives, olives, sweet peppers, chopped nuts, etc., for the sake of adding flavor. Cooked egg yolk, spinach extract, etc., are sometimes mixed in for the sake of color. If the balls are rolled in chopped chives or parsley, both flavor and color are supplied.

Plain Cheese Salad.

Cut Edam or ordinary American cheese into thin pieces, scatter them over lettuce leaves, and serve with French dressing.

Olive and Pimiento Sandwich or Salad Cheese.

Mash any of the soft cream cheeses and add chopped olives and pimientos in equal parts. This mixture requires much salt to make it palatable to most palates, the amount depending chiefly on the quantity of pimiento used. The mixture may be spread between thin slices of bread or it may be made into a roll or molded, cut into slices, and served on lettuce leaves with French dressing.

Cheese and Tomato Salad.

Stuff cold tomatoes with cream cheese and serve on lettuce leaves with French dressing.

Cheese and Pimiento Salad.

Stuff canned pimientos with cream cheese, cut into slices, and serve one or two slices to each person on lettuce leaves with French dressing.

Cheese Jelly Salad.

½ cupful of grated cheese.
1 tablespoonful of gelatin.
1 cupful of whipped cream.
Salt and pepper to taste.

Mix the cheese with the whipped cream, season to taste with salt and pepper, and add to the gelatin dissolved in a scant cupful of water. This may be molded in a large mold or in small molds.

When the jelly begins to harden, cover with grated cheese. The jelly should be served on a lettuce leaf, preferably with a cream dressing or a French dressing, to which a little grated cheese has been added.

Cheese Salad and Preserves.

Epicures have devised a dish which consists of lettuce with French dressing served with cream cheese and thick preparations of currants or other fruits preserved in honey or sugar, which, owing to the fact that the seeds have been extracted by a laborious process, are fairly expensive. The soft cheese often found in market is also relatively expensive. There is a suggestion in this dish, however, for others which are much less costly. Buttermilk cream (see p. 21), or ordinary cottage cheese served with lettuce or other green salad and a small amount of rich homemade preserves, is a combination with much the same character, and also very appetizing.

Deviled Eggs with Cheese.

In making deviled eggs, either to be eaten alone or upon lettuce leaves in the form of salad, a little grated cheese may be mixed with the yolks in addition to the usual salad dressing and flavorings with which the yolks are mixed.

Cheese and Celery.

Cut stalks of celery having deep grooves in them into pieces about 2 inches long. Fill the grooves with cream cheese salted or flavored with chopped pimientos, and serve with bread and butter as a salad course or serve as a relish at the beginning of a meal.

Although not cheese dishes, strictly speaking, the following salad dressings made with buttermilk cream (see p. 21) may be included in this section.

Buttermilk Cream Salad Dressing.

½ cupful of buttermilk cream (see p. 21).
1 tablespoonful of vinegar.
¼ teaspoonful of salt.
Cayenne pepper.

This dressing is particularly suitable for serving with cucumbers.

Buttermilk Cream Horseradish Salad Dressing.

To buttermilk cream add a little grated horseradish and vinegar and salt. Serve on whole or sliced tomatoes.

Cheese Sandwiches.

Mash or grate American cheese, add salt, a few drops of vinegar and paprika, and a speck of mustard. Mix thoroughly and spread between thin slices of bread.

Cheese and Anchovy Sandwiches.

To the mixture mentioned in the preceding recipe, add a little anchovy essence. Sardines mashed or rubbed into a paste or any other fish paste may be used in a similar way.

Pimiento, Olive, and Cheese Sandwiches.

These sandwiches are referred to on page 34.

Cuban Sandwiches.

This sandwich may be described as a kind of club sandwich with cheese. It is usually made large so that it is necessary to eat it with a knife and fork. It may be made in such proportions as to supply a large amount of nourishment.

Cut the crusts from slices of bread. Between two slices lay first lettuce with a little salad dressing or salt on it, then a slice of soft mild cheese and finally thin slices of dill pickles or a little chopped pickle.

Toasted Cheese Sandwiches.

Plain bread and butter sandwiches with fairly thick slices of cheese put between the slices are frequently toasted, and on picnics, or at chafing-dish suppers, are often browned in a pan in which bacon has just been fried.

CHEESE PASTRY, CHEESE SWEETS, AND SIMILAR DISHES.

In the foregoing pages a large number of recipes have been included in which cheese is combined with materials without cooking, as in salads, or used in cooked dishes of creamy or custard-like consistency, as in soufflés and Welsh rabbit or in combination with vegetables or cereals, such as rice.

There are a number of cheese dishes of quite different character in which the cheese is combined with dough, batter, or pastry in various ways, and a number of dishes in which cheese or cheese curd is used in combinations suitable for dessert. Such sweet dishes were once much more common than they are to-day, as reference to old cookery books will show, but some of them are well worth retaining.

In cheese sweets, flavor and richness are both contributed by the cheese.

When cheese is used in pastry or dough it may serve simply as a flavor, as in cheese sticks or cheese straws, or it may wholly or in part replace with its fat the usual shortening, as butter or other fat, and with its protein (casein) the protein (albumin) of eggs. As an illustration of such a use of cheese, cheese gingerbread may be cited.

Using cheese in this way is often an economy when eggs are scarce. Better results will be obtained if soft cheese is used which can be worked into the dough in much the same way as butter or other shortening. To those who like cheese the flavor which it imparts would be an advantage. However, if a very mild cheese is used in combination with molasses or spice the dish differs a little in flavor from one prepared in the usual way.

CHEESE PASTRIES AND SIMILAR DISHES.

Cheese Biscuit No. 1.

2 cupfuls of flour.
4 teaspoonfuls of baking powder.
2 tablespoonfuls of lard or butter.
⅞ of a cup of milk.
¼ teaspoonful of salt.
Grated cheese sufficient to give desired flavor.

Mix all the ingredients excepting the cheese as for baking powder biscuits. Roll thin, divide into two parts, sprinkle one half with grated cheese, lay the other half of the dough over the cheese, cut out with a small cutter, and bake.

Cheese Biscuit No. 2.

¼ pound of soft cheese.
2 cupfuls of flour.
1 cupful of water.
4 teaspoonfuls of baking powder.
1½ teaspoonfuls of salt.

Mix and sift the dry ingredients, then work in the cheese with a fork or with the fingers, and add the water gradually. The approximate amount of water has been given; it is impossible to give the exact amount, as flour differs in its capacity for taking up moisture. Toss the dough on a floured board and roll out and cut with a biscuit cutter. Place in a buttered pan and bake in a quick oven from 12 to 15 minutes. The biscuit may be sprinkled with cheese before being put into the oven.

If the cheese is sufficiently soft it can be measured just as butter is. This recipe, then, would call for ½ cupful.

Cheese Drops.

2½ tablespoonfuls of milk.
1 teaspoonful of butter.
1¼ cupfuls of flour.
⅛ teaspoonful of salt.
1 egg.
2 tablespoonfuls of grated Parmesan cheese or dry American cheese.

Heat the butter and milk to boiling point, add the flour and the salt and stir thoroughly. Remove from the fire, add the egg and cheese and stir until well mixed. When cold, drop in small pieces in deep fat and brown. This makes a good addition to any clear soup or to consommé.

Cheese Wafers.

Spread grated cheese on thin crackers, heat in the oven until the cheese is melted. Serve with soup or salad.

Cheese Relish.

Spread bread which has been toasted or fried in deep fat with grated cheese, or with grated cheese mixed with a little mustard, then heat in the oven until the cheese is melted. This may be served with salad, or as a relish to give flavor to some dish such as boiled rice or hominy, which has no very marked flavor.

Cheese Straws.

Roll out plain or puff paste until one-fourth of an inch thick. Spread one-half of it with grated cheese. Fold over the other half and roll out again. Repeat the process three or four times. Cut into strips and bake. Serve with soup or salad.

Salad Biscuit.

½ pound of cheese.
2 cupfuls of flour.
4 teaspoonfuls of baking powder.
1½ teaspoonfuls of salt.
1 cupful of water.

Mix as for cheese biscuits No. 1 or No. 2, depending on whether the cheese is hard or soft. (See p. 36.)

Cheese Gingerbread No. 1.

1 cupful of molasses.
4 ounces of cheese.
1 teaspoonful of soda.
½ cupful of water.
2 cupfuls of flour.
2 teaspoonfuls of ginger.
½ teaspoonful salt.

Heat the molasses and the cheese in a double boiler until the cheese is melted. Add the soda and stir vigorously. Mix and sift dry ingredients and add them to the molasses and cheese alternately with the water. Bake 15 minutes in small buttered tins.

Cheese Gingerbread No. 2.

½ cupful of molasses.
½ cupful of sugar.
4 ounces of cheese.
2 cupfuls of flour.
1 teaspoonful of soda.
2 teaspoonfuls of ginger.
½ teaspoonful of salt.
¾ cupful of water.

Rub the cheese and the sugar together. Add the molasses. Mix and sift the dry ingredients and add them to the cheese mixture alternately with the water.

Cheese Custard.

1 cupful of grated cheese.
½ cupful of cream or rich milk.
Yolks of 2 eggs.
A speck of salt and of paprika.

Mix the cream and the cheese and heat until the cheese is melted. Remove from the fire and add the yolks of the eggs. Bake in paper cases or buttered ramekins. Serve with jelly or preserves.

Cheese Cakes.

1 quart of milk.
Rennet.
1 ounce of sugar.
Yolks of 2 eggs.
A speck of nutmeg.
1½ ounces of butter.
1 ounce of dried currants or small raisins.

Warm the milk and add the rennet, using the amount prescribed on the package. Let the milk stand until the curd forms, then break up the curd and strain off the whey. Add the other ingredients to the curd; line patty tins with pastry, fill them with the mixture, and bake.

Brown Betty with Cheese.

Arrange in a deep earthenware baking dish, alternate layers of bread crumbs and thinly sliced apples. Season with cinnamon, also a little clove if desired and brown sugar. Scatter some finely shaved mild full-cream cheese over each layer of apple. When the dish is full, scatter bread crumbs over the top and bake 30 to 45 minutes, placing the dish in a pan of water so that the pudding will not burn.

If preferred, this may be sweetened with molasses mixed with an equal amount of hot water and poured over the top, a half cupful of molasses being sufficient for a quart pudding dish full.

Cheese may be used in place of butter in a similar way in other apple puddings. Apple pie made with a layer of finely shaved cheese over the seasoned apple and baked in the usual way is liked by many who are fond of cheese served with apple pie.

CONCLUSION.

In the foregoing pages information has been summarized regarding the food value of cheese, an important agricultural product, and ways of preparing it for the table. It has been pointed out that, judged by the kind of nutrients it supplies—chiefly nitrogenous material and fat—and the proportion in which they are present, it resembles such foodstuffs as meat, fish, and eggs, which means that like them its rational use in the diet is in combination with other staple foods, to form well-balanced meals.

Experiments have shown that when eaten either raw or carefully cooked, cheese is as thoroughly digested as other staple foods and is not likely to produce physiological disturbance.

An ounce of cheese roughly is equivalent to 1 egg, to a glass of milk, or to 2 ounces of meat.

Although uncooked cheese resembles meat in composition, cheese dishes prepared after ordinary recipes, with milk and shortening, are likely to contain more fat than meat dishes prepared in the usual ways. When, therefore, such cheese dishes are served with other staple foods the combination is likely to contain more fat than the usual meal. If little fat is ordinarily used, this may be an advantage. If a great deal of fat is ordinarily used, it may be desirable to lessen the amount in the cheese dishes. This can readily be done by omitting the shortening and using skim milk or water in the preparation of such dishes, a change which also lessens their cost.

The fact that cheese, like meat, contains neither starch nor cellulose suggests that, like meat, it should be combined with bread, potatoes, and other starchy foods, with vegetables and with sweets. The concentrated character of cheese and many cheese dishes suggests the use of succulent fruits and vegetables with them. The high percentage of fat in cheese suggests the use of correspondingly small amounts of fat in the accompanying dishes, while the soft texture of cheese dishes as compared with meat makes it reasonable to serve the harder and crustier breads with them.

When cheese is not used as the chief nitrogenous food of a meal it may be introduced into bills of fare in many incidental ways, and thus add materially to that portion of the diet needed for building and repairing body tissue.

Though cheese is so generally used in some way in most families, yet the making of menus with cheese as a central dish is less well understood than more usual food combinations, since there is less experience to serve as a guide. More thought is therefore usually required to arrange such cheese meals in order that they may be palatable and at the same time reasonable in nutritive value.

In order that the diet may remain well balanced, cheese, if used in quantity, should replace foods of similar composition rather than supplement them. The builder who has a choice of materials must have a knowledge of their relative properties if he wishes to use stone instead of brick, or wood in place of iron. It is the same with the housekeeper who wishes to use her available food supply intelligently and whose choice of foods is influenced by their relative cost at a given time or season. The woman who has a knowledge of the relative food value of different articles of diet, and their real food qualities as distinguished from their market value, who understands good methods of cooking and serving foods, and who plans her meals and other housework so that unnecessary labor and expense may be avoided, is taking account of the things which make for economical living as well as for good living.

Some persons seem to believe that cheese or fish or other food is the ideal food for some particular circumstance and that there is a special food or diet suited to each kind of work and to every circumstance of our daily life, and that it would be a great advantage if we could regulate our daily fare with the accuracy a chemist uses in making an experiment. Work, recreation, the amount of clothing we wear, and other details of our daily life are not so regulated, and it is the belief of those who have studied the subject that the best interests of persons living under normal conditions are served if the ideal be rather the regulation of the diet along general lines in accordance with good sense, the teachings of experience, economy, and the available knowledge gained from a scientific study of the subject, due care being taken that the different staple foodstuffs are so combined that all the needs of the body are provided, excessive waste is prevented, and that both undernourishment and excess or overeating are avoided.

Dishes which are liked and the methods followed in preparing them will vary in different countries and at different times, yet this does not of necessity mean that the nutritive value of the diet varies correspondingly. In the same way it is possible for us to vary the selection of our foods and the character of our diet at will, according to the demands of our taste and our purse, without correspondingly changing its value for supplying the needs of the body. This means that the housekeeper, in suitable ways, can use cheese, meat, fish, eggs, and other foods of similar composition as substitutes for one another, being governed by their relative market value at different times and seasons, by the tastes of her family, and similar considerations. If she uses the different foodstuffs with reference to their nutritive value and is skillful in preparing foods in appetizing ways and in serving them in attractive combinations, the daily fare may be both adequate and pleasing, whether she selects cheese or meat or fish or eggs or other foods to supply nitrogenous material and fat. Here, as in all that pertains to housekeeping, true economy is dependent upon a knowledge of materials and skill in using them.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

O

Issued April 15, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

SUPERSEDED BY 1439

FARMERS' BULLETIN 488.

DISEASES OF CABBAGE AND RELATED CROPS AND THEIR CONTROL.

BY

L. L. HARTER,

Pathologist, Cotton and Truck Disease and
Sugar-Plant Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 30, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Diseases of Cabbage and Related Crops and Their Control," by Mr. L. L. Harter, Pathologist in the Office of Cotton and Truck Disease and Sugar-Plant Investigations.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction ... 5
Classification of the cabbage industry ... 5
How the various diseases are disseminated ... 7
  Insects ... 7
  Infected seed ... 7
  Transplanting ... 7
  Drainage water ... 8
  Stable manure and compost ... 8
  Distribution by animals ... 9
  Dissemination by wind ... 9
Farm practice and its relation to the control of diseases ... 9
  Disinfection of seed ... 9
  Care and preparation of the seed bed ... 10
  Crop rotation ... 11
  Fungicides ... 12
Important cabbage and cruciferous diseases ... 12
  Classification ... 12
  Clubroot (clubfoot, finger and toe) ... 13
    Description ... 13
    Control ... 13
    Distribution and loss ... 14
    Cause ... 14
  Root-knot (nematodes) ... 14
    Description ... 14
    Control ... 15
    Distribution and loss ... 16
    Cause ... 16
  Black-rot (brown-rot, stem-rot, dry-rot) ... 16
    Description ... 16
    Control ... 17
    Distribution and loss ... 17
    Cause ... 17
  Wilt (yellows, yellow-sides) ... 18
    Description ... 18
    Control ... 20
    Distribution and loss ... 20
    Cause ... 20
  Black-leg (foot-rot, wilt) ... 21
    Description ... 21
    Control ... 23
    Distribution and loss ... 23
    Cause ... 24
  Soft-rot ... 24
    Description ... 24
    Control ... 25
    Distribution and loss ... 25
    Cause ... 25

Important cabbage and cruciferous diseases—Continued. Page.
Malnutrition, a physiological disease ... 25
Description ... 26
Control ... 27
Distribution and loss ... 28
Cause ... 28
Downy mildew ... 29
Description ... 29
Control ... 29
Distribution and loss ... 29
Cause ... 29
White-rust ... 30
Control ... 30
Distribution ... 30
Cause ... 30
Spot disease of cauliflower ... 30
Leaf-blight (black mold) ... 31
Description ... 31
Control ... 31
Distribution and loss ... 31
Powdery mildew ... 31
Damping-off ... 31

ILLUSTRATIONS.

Page.
Fig. 1. Enlarged roots of cauliflower caused by the clubroot organism ... 13
2. Enlarged roots of cabbage caused by nematodes ... 15
3. Sections through a cabbage stem showing the conspicuous ring of black bundles caused by the black-rot organism ... 18
4. A cabbage plant showing the characteristic symptoms of wilt or yellows ... 19
5. A cabbage leaf showing injury from the black-leg organism ... 22
6. A field of cabbage with 75 per cent of the plants killed by the black-leg fungus ... 24
7. A cabbage leaf showing the characteristic symptoms of malnutrition ... 26

B. P. I.—726.

DISEASES OF CABBAGE AND RELATED CROPS AND THEIR CONTROL.

INTRODUCTION.

Cabbage is one of the most widely distributed and cultivated of our farm crops and at the present time is found in the garden of nearly every farmer. As long as the crop was grown only for home consumption the various diseases which attack it attracted little or no attention. In more recent years, however, cabbage growing has become a very important industry and now exists on a commercial scale in many parts of the United States. With the extension of the industry the diseases of the crop have increased in severity to a degree where they have reached economic importance. Unless some means are employed to check them there is danger that the industry will be forced out of its present centers. Such an event would result in the loss of large sums of money by those men who have constructed and maintained large sauerkraut factories and storage houses and would deprive many farmers of a very profitable cultivated crop.

From the original wild stock of cabbage have come cauliflower, Brussels sprouts, kohl-rabi, collards, and kale. Other cultivated crucifers closely related to those already mentioned are turnips, radishes, rape, broccoli, rutabaga, and charlock. Among the related wild plants shepherd's purse, peppergrass, and mustard are of most frequent occurrence. Mustard is sometimes cultivated, but it grows so profusely under all conditions that it is perhaps better classed as an obnoxious weed.

Practically all the crucifers mentioned are subject to the same diseases, so that any method for the control of the diseases of cabbage or cauliflower, for example, can be applied to other crucifers as well.

CLASSIFICATION OF THE CABBAGE INDUSTRY.

There are five classes of farmers who engage in the cultivation of cabbage and who, therefore, are especially interested in the different diseases: (1) The farmer who cultivates a variety of crops and grows cabbage only for home use; (2) the trucker who grows an early spring crop which is immediately sold on the market and consumed as a green vegetable; (3) the farmer who grows a late summer or fall crop for the sauerkraut manufacturers; (4) the farmer who grows a late crop for storage purposes; and (5) the seed grower.

The general farmers, with the exception of those who grow cabbage on a commercial scale, have at most only small patches, so that the aggregate total acreage grown by them is small. But the family garden used by the great majority of growers and limited to a small area upon which cabbage, cauliflower, or other crucifers are grown year after year on the same ground provides the most favorable conditions for the perpetuation of the various diseases.

The truckers are located mostly in the Southern States or in the Eastern States along the Atlantic seaboard in the vicinity of the large cities. In the Southern States the cabbage crop is planted in the fall, winter, or early spring, and after marketing is immediately followed by some other crop. In the more northern districts the crop is planted in the spring.

The trucker works the ground intensively, obtaining from the same land in a single year two, three, or even four different crops. According to the system of rotation generally followed cabbage would appear on the same ground about every second or third year.

The manufacture of sauerkraut forms an important industry in some of the Northern States, more particularly Ohio, Michigan, and Wisconsin. The manufacturers depend upon a late summer or fall crop. The yield of cabbage grown for this industry has been greatly reduced in recent years by the invasion of several destructive diseases which now threaten to exterminate it or force it out of its present centers.

In some of the Northern States, especially New York and Wisconsin, many farmers grow a late crop to be placed in storage to supply the winter demand for fresh cabbage. In these districts also the invasion of diseases has greatly reduced the yield. Diseased heads do not keep well when placed in storage. In an unfavorable season the yield in some of the districts where cold storage is practiced has been reduced 50 to 60 per cent. From 25 to 40 per cent of the heads that go into storage are frequently lost from decay or rendered unfit for marketing.

Most of the seed of cabbage, cauliflower, and related crops is grown either on Long Island, N. Y., or near Puget Sound, Wash., or is imported. It is especially important that it be grown on soil free from the diseases of all crucifers, since it is possible that some of the worst pests may be distributed to various parts of the country with the seed. The care with which the seed is produced, therefore, is of great importance to every farmer wishing to grow any of these crops.

HOW THE VARIOUS DISEASES ARE DISSEMINATED.

Fungous and bacterial diseases are carried from one place to another by various means, such as (1) insects, (2) infected seed, (3) transplanting from an infected seed bed to the field, (4) drainage water, (5) stable manure and compost, (6) animals, and (7) wind.

INSECTS.

Insects are potent factors in the distribution of some diseases. It has been shown that the bacteria causing the black-rot of cabbage have been carried from one plant to another and from one leaf to another by slugs, snails, etc. Insects which visit cabbage and other crucifers are likely to carry the germs on their bodies and deposit them on the parts of noninfected plants. If other conditions are favorable, infection then takes place.

Certain insects are attracted to diseased areas of plants by the odors emitted therefrom. Cabbage affected with clubroot has a very offensive odor at some stages in the development of the disease. Insects frequent the roots, and before the disease was thoroughly studied they were supposed to be the cause of it. Later observations, however, showed that they were attracted to the decayed roots by the odor and were in no way connected with the cause of the disease. New infections may be brought about by these insects visiting other plants.

INFECTED SEED.

Growers of cabbage for the market seldom raise their own seed, but purchase it from seed growers. The same can be said of cauliflower and other related plants. If the seed is grown where diseases are prevalent it is possible that the disease may be introduced with the seed. The germs of some of our worst plant diseases, the black-rot of cabbage in particular, have been found to live on the seed for several months. For this reason it is always advisable, as a precautionary measure, to treat the seed with some disinfectant before sowing. (See p. 9.)

TRANSPLANTING.

Plants that are started in a crowded seed bed, which is often located on old ground near the house or in the garden, are frequent carriers of diseases to a noninfected field. In such crowded conditions diseases are readily communicated from one plant to another. Some of the diseases of cabbage and cauliflower, such as clubroot, are known to be distributed to some extent by insects. The insects, burrowing through the ground or feeding upon the roots, carry the disease from the roots of one plant to those of another. If care is exercised to prevent the disease in the seed bed by the proper disinfection of the seed and the seed bed before sowing, the loss in the field can be greatly reduced.

DRAINAGE WATER.

Drainage water or the run-off during heavy rains probably furnishes one of the most important means for the dissemination of plant diseases and has been found in many places to explain the presence of a disease in fields where cabbage or other crucifers have never before been grown. If the crop is planted on high ground the germs from the refuse of diseased plants may be washed to the low-lying fields during heavy rains. In the hope of avoiding the disease by crop rotation a new field on this low ground may be selected, where the disease will prove as severe as on the abandoned field.

In some sections where cabbage is grown on a commercial scale it is customary to set the plants with a machine which drops about a half pint of water for each plant. For this purpose the water from drainage ditches, which is often the run-off from a field where some bad disease has been present, being the most available, is frequently used. This use furnishes another method of spreading disease, as was illustrated in a field set to cabbage for the first time, which came under the writer's observation. The water used in setting a part of the field was obtained from a well; for the remainder, water from a drainage ditch adjacent to a field planted to cabbage the previous year was used. The plants set in both portions of the field were secured from the same seed bed. The wilt, or yellows, was very severe where the plants were set with water from the drainage ditch; the other part of the field was free from it.

STABLE MANURE AND COMPOST.

A not uncommon practice is for farmers to throw the refuse of cabbage or other crops on the manure heap, the compost thus formed being hauled out and distributed on the fields the following spring. This is a bad practice if the crop is diseased, as the causal organism may thereby be readily disseminated. The value of cabbage leaves as a fertilizer or, in fact, the leaves of any crucifers, is very doubtful. Cabbage leaves contain 85 to 90 per cent of water and the leaves of other crucifers nearly as much, so that even though all the dry matter might be valuable as a fertilizer it would be so small as to be practically negligible. Rather than take the risk of spreading some parasitic disease it would be far better to collect the refuse from infected fields and burn it.

DISTRIBUTION BY ANIMALS.

In order to avoid what may seem an apparent waste, farmers frequently turn their stock in the fields to feed upon any roughage that may be found after a crop is harvested. Cattle and sheep are especially fond of cabbage leaves and by eating them they may carry serious diseases to other fields, as the causal organism may pass unharmed through the alimentary canal. In addition to this the spores may be, and often are, carried on the feet of animals, so that free access to the whole farm increases the possibility of communicating diseases from one field to another.

DISSEMINATION BY WIND.

Dissemination by wind is perhaps not so important a factor in the distribution of diseases of cruciferous plants as some already mentioned. Nevertheless, in certain districts where the soil is light, where dry weather prevails a part of the year, and high winds are common, spores may be carried long distances. The diseases that are external to the leaves are more likely to be distributed in this way than parasites which are situated in the soil or in the internal portion of the plant.

FARM PRACTICE AND ITS RELATION TO THE CONTROL OF DISEASES.

Several methods by which diseases may be carried from one plant to another, from one field to another, or, indeed, from one part of the country to another have already been pointed out. In view of these facts the first aim of the farmer should be to prevent, if possible, the introduction and distribution of destructive diseases on his farm. In order to accomplish this several precautions should be observed, of which the more important are: (1) The disinfection of seed, (2) the preparation and care of the seed bed, (3) crop rotation, and (4) the application of fungicides.

DISINFECTION OF SEED.

Farmers who grow cabbage, cauliflower, and other crucifers as market-garden crops seldom produce their own seed. Seed growing is an industry in itself and requires quite different cultural methods from those necessary to grow a market crop. It has been found that certain soils and climates are better suited than others for seed production. Because of this fact most of the cabbage seed is grown on Long Island, or near Puget Sound, or is imported. The men engaged in this industry are not especially interested in obtaining seed free from disease germs, and it is possible that some of the worst diseases of these crops have been distributed from these centers by means of the seed. The farmer, therefore, should guard against the introduction of dangerous maladies by disinfection of the seed before sowing it in the seed bed or in the field. "An ounce of prevention is worth a pound of cure." The seed of cabbage, cauliflower, turnips, and other crucifers should be disinfected according to the following method:

Formaldehyde (40 per cent)	¼ pint.
Water	7 gallons.

The seed should be left in the solution about 15 minutes, dipped in pure water to wash off the formaldehyde, and then spread out to dry. Even greater strengths of formaldehyde can be used without injury to the seed if care is exercised to wash and dry thoroughly.

CARE AND PREPARATION OF THE SEED BED.

Cabbage, cauliflower, and some other plants of the same family are generally started in a seed bed before being set into the field. As previously pointed out, some of the worst diseases of these crops may be transferred by means of the plants from the seed bed to noninfected fields. In order to grow strong, vigorous plants as quickly as possible compost or stable manure is mixed with a good quality of soil to form the seed bed. The mistake is often made of placing the bed on an old cabbage field where diseases may have been present, because the soil happened to be fertile or for other reasons. Furthermore, the manure might be, and often is, taken from the heap where diseased plants have been thrown to compost, or it may be from animals that have fed on diseased cabbage. In either case there would be great danger of introducing the diseases into the seed bed. The transfer of such plants to the field would naturally mean the transfer of the diseases affecting them.

Mr. W. W. Gilbert, of the Bureau of Plant Industry, recommends the following methods for disinfecting the seed beds: (1) Steam sterilization by means of draintile laid in the bottom of the beds, through which steam is passed; (2) sterilization by means of an inverted pan under which steam is admitted; (3) sterilization by drenching the soil with a formalin solution; or (4) treating soil with Bordeaux mixture.

In the tile method of steaming, lines of 2-inch to 3-inch glazed tile are placed lengthwise in the beds to be sterilized, 2 to 2½ feet apart and 15 inches below the surface, and are left there permanently. They provide drainage for the beds, may be used for subirrigation, and are available at any time for sterilizing the soil, the only outlay for labor being the covering of the beds with boards or a tarpaulin and the connecting of the tile with a boiler by means of a piece of steam hose. The soil need not be moved, and thus a large part of the labor involved in sterilization is obviated. It is advisable, however, to spade up the soil so that the steam may more readily penetrate it.

Another method of steaming, by means of an inverted galvanized-iron pan, 6 by 10 feet and 6 inches deep, under which steam is admitted, has been used to a limited extent in the sterilization of tobacco seed beds and in greenhouse beds and has given very satisfactory results. The use of steam at a pressure of 80 to 100 pounds and treatment for from one-half hour to an hour after the soil has reached a temperature of 212° F., as indicated by soil thermometers, has given the best results.

Formalin sterilization is accomplished by drenching the soil with a 1 to 100 or 1 to 200 solution of formalin, at the rate of three-fourths of a gallon per square foot of area, several days before the soil is to be used. Formalin, however, does not rid the soil of nematodes, as steaming does. This method has been used to good advantage in the sterilization of lettuce beds for the prevention of fungous diseases. For more detailed directions for soil sterilization by the methods here outlined, see Bulletin No. 158 of the Bureau of Plant Industry, entitled "The Root-Rot of Tobacco Caused by Thielavia Basicola."

Another method of soil sterilization in the seed bed, which the Ohio Agricultural Experiment Station has found successful in controlling the black-leg of cabbage, consists in treating the bed immediately after sowing the seed with a solution of Bordeaux mixture (4–4–50 formula) at the rate of 1 gallon per 10 square feet. In addition to this the beds should be sprayed about two weeks before and again just preceding transplanting into the field.

If it is found impracticable to disinfect the seed bed by any of the foregoing methods new soil should be used and stable manure, if mixed with it, should be obtained from some source where there is little or no chance for diseases to be present.

CROP ROTATION.

Crop rotation is an essential practice whether or not it is necessary in the control of any plant maladies. There are numerous fungous diseases which reappear year after year on the same field if a suitable host is present. Some of them, such as the clubroot of cabbage, are strictly soil parasites and can not be controlled by any fungicide. About the only method left to get rid of the organism is to starve it out, and this can be done only by a well-planned system of crop rotation. Most of the organisms like the clubroot of cabbage have a number of hosts on which they live, any one of which will serve to perpetuate the disease. It is therefore necessary to avoid planting in close succession crops that are affected with the same parasites.

The length of the rotation depends largely upon the disease and the thoroughness with which the system is carried out. There are only a few diseases that will be killed out by a three or four year rotation, and instances are known where one of six or seven years has failed to eradicate the malady, though its severity was greatly reduced. There are several reasons why long rotations are frequently necessary. (1) Many weeds which are overlooked by the farmer during cultivation perpetuate the diseases. (2) Certain parasites are able to live for a time on decayed vegetative matter when a suitable host is not available. Just to what extent this is the case is not definitely known. (3) Some fungi have the ability to remain dormant for a considerable length of time in the absence of a suitable host. The organism causing the wilt of cabbage, for example, has been known to be dormant in dry soil for three and one-half years and then to produce the disease. For ordinary practice, however, a rotation of four or five years is sufficient to reduce greatly the loss from most parasites. Deep and frequent cultivation by means of which the organisms are exposed to the air and sunshine assists in exterminating them.

FUNGICIDES.

The leaf diseases of cabbage, cauliflower, and related crops are relatively so unimportant that spraying is seldom required. The most important diseases are internal or soil parasites and out of the reach of fungicides.

IMPORTANT CABBAGE AND CRUCIFEROUS DISEASES.[1]

CLASSIFICATION.

The following is a classification of the most important diseases of cabbage and cruciferous plants, with the pages of this bulletin on which they are discussed:

	Page.
DISEASES OF THE ROOT:	
Clubroot (clubfoot, finger and toe)	13
Root-knot (nematodes)	14
DISEASES AFFECTING ROOT, STEM, AND LEAVES:	
Black-rot (brown-rot, stem-rot, dry-rot)	16
Wilt (yellows, yellow-sides)	18
Black-leg (foot-rot, wilt)	21
Soft-rot	24
Malnutrition	25
DISEASES OF THE LEAF ONLY:	
Downy mildew	29
White-rust	30
Spot disease of cauliflower	30
Leaf-blight (black mold)	31
Powdery mildew	31
DISEASES OF YOUNG SEEDLINGS:	
Damping-off	31

---

[1] Various names are often applied to the same disease, as shown in this classification.

CLUBROOT (CLUBFOOT, FINGER AND TOE).

Description.—Plants affected with clubroot, even in the presence of abundant moisture, show in the earlier stages a wilting of the foliage in the sunshine, which recovers toward evening or when cloudy weather comes on. They are characterized by malformations of the roots in the form of swellings (fig. 1), sometimes as large as two fists. Few or no lateral feeding roots are formed. The disease generally attacks the plants when young, often in the seed bed, and plants so affected have a stunted, sickly appearance. Diseased plants seldom grow to maturity. The clubroot of crucifers might be confused with root-knot, which is characterized by similar enlargements of the roots caused by a minute eelworm, or nematode. The malformations caused by nematodes, however, are usually not so large. While present to some extent in the North, especially in greenhouses, root-knot is more commonly met with in the South. Clubroot, on the other hand, is more prevalent in the Northern States.

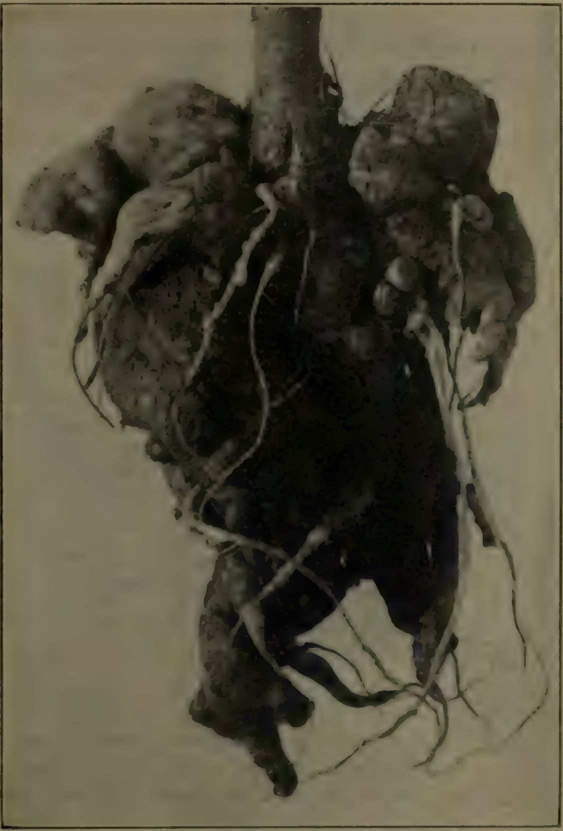


FIG. 1.—Enlarged roots of cauliflower caused by the clubroot organism.

Control.—The clubroot organism is a soil parasite and for that reason recourse must be made to some form of soil treatment. The organism thrives best in an "acid" soil and in view of this fact slaked lime at the rate of about 75 bushels per acre added every few years will keep the disease in check. The lime should be added some months before planting. If the crop is to be planted early in the spring the lime should be applied the previous fall, but if a late planting is desired it can be put on in the spring.

Seedlings are very susceptible to the disease, and the utmost precaution must be taken to grow the plants on uninfected soil, or disinfection of the seed bed should be practiced. Furthermore, diseased plants should be destroyed by burning and should not be thrown on the manure pile or left in the field. Crop rotation should be practiced, and as it has been found that the disease will live in the soil for several years the rotation should be a long one. All cruciferous weeds should be destroyed, and no cultivated crucifers should be used in the rotation. The disease has been found in this country on cabbage, cauliflower, rutabaga, turnips, radishes, Brussels sprouts, and mustard among the cultivated plants and on some of the weeds of the same family. It probably occurs on many others.

No variety of these crops is known to be positively resistant to clubroot, though the Hollander variety of cabbage is claimed by some growers to be partially resistant. It has also been observed that the varieties of blue or red cabbage are less susceptible to clubroot than the Succession variety. Unfortunately, however, though apparently more resistant, these colored types are not good for all commercial purposes as, for example, the manufacture of sauerkraut.

Distribution and loss.—Clubroot has been known in Europe for more than a century. It occurs in England, Holland, Russia, and other European countries. Its presence in Australia has been known for a number of years. It has also been reported from New Zealand and from 20 States in this country and probably occurs in many more. It is present over most of the country east of the Mississippi River.

In some seasons from 40 to 50 per cent of the crop in the affected fields is lost by this disease. As early as 1876 Woronin estimated the loss near St. Petersburg, Russia, at more than $200,000.

Cause.—Although clubroot was known to occur in Europe more than a century ago, its true cause was not known until 1876, when Woronin, a Russian botanist, found it to be due to a slime mold, one of the lowest forms of life, and gave it the name *Plasmodiophora brassicae* Wor. Previous to that time, insects were suspected to be the cause of the disease, largely because they were frequently present in the swellings of the roots. It is now known that they are attracted by the odor of the decaying roots.

The slime mold causing clubroot is composed of a plasmodium, or mass of motile protoplasm, situated within the tissue of the host. The plasmodium subsequently breaks up into innumerable microscopic spherical spores. Upon the germination of these spores the contents escape as irregular protoplasmic masses (zoospores). This is sometimes spoken of or called the swarm-spore stage. The zoospores are provided with a cilium, a tail-like appendage, by means of which they propel themselves from one place to another. In their unprotected state the zoospores can not survive long, so they must either find a suitable host or perish. When they come in contact with the proper host they enter the tender roots and form anew the plasmodium.

ROOT-KNOT (NEMATODES).

Description.—Some confusion is likely to result in trying to distinguish between root-knot and clubroot. While the organisms causing the two diseases are quite different, the effects produced on the roots bear some points of resemblance. (Compare figs. 1 and 2.) Root-knot, as a rule, is characterized by smaller swellings than clubroot, more of the lateral feeding roots are affected, and the nodules are located nearer the tips of the roots. If upon breaking open the swellings on the roots pearly white bodies about the size of a pinhead are found, root-knot is to be suspected. These white specks within the swellings are the enlarged egg-bearing female eelworms, which cause the disease. The interior mass of clubroot is slightly pinkish or brickcolored. Root-knot affects a great variety of unrelated plants, while clubroot, so far as known, occurs only on crucifers.

Furthermore, root-knot is confined largely to the light, sandy soils in the South, although it may occur in the Northern States, while clubroot is seldom found in the South and may occur on either heavy or light soil.

Control.—Crop rotation has been found to be a most effective means of controlling this disease, the object being to use crops immune to root-knot for the purpose of starving out the worms. When this method of eradicating the disease is employed, a rotation of at least three years, accompanied by clean cultivation, should be practiced. There are some 480 different species of plants already known to be susceptible to root-knot, among which are many cultivated plants and numerous weeds. Crops known to be immune to the disease that can be used in the rotation are corn, oats, rye, timothy, pearl millet, sorghum, wheat, crab-grass, the Iron cowpea,

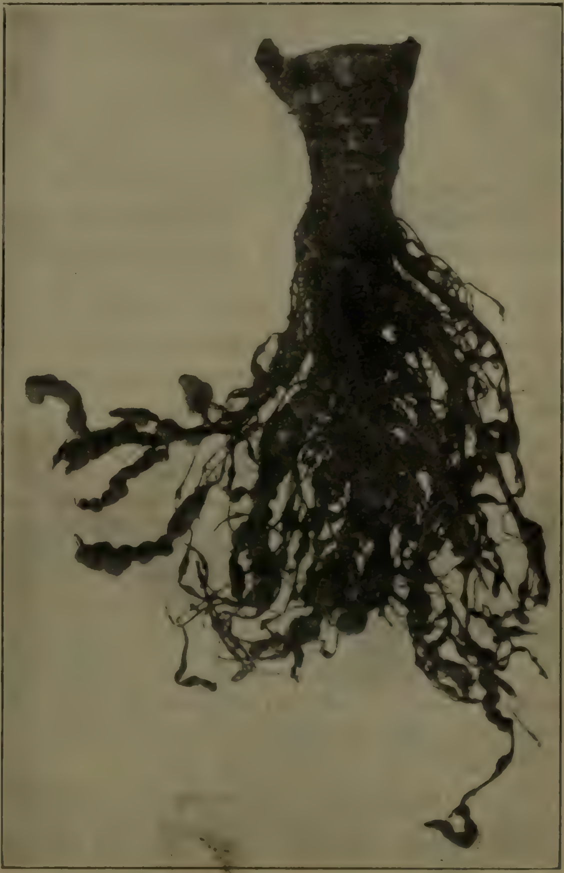


FIG. 2.—Enlarged roots of cabbage caused by nematodes.

velvet beans, peanuts, and beggarweed. Some of the cultivated crops susceptible to the disease and therefore to be avoided in the rotation are alfalfa, vetch, soy beans, cowpeas (except the Iron), clover, sugar cane, tomatoes, okra, cucumbers, cantaloupes, watermelons, celery, beans, sweet potatoes, tobacco, potatoes, peaches, figs, mulberries, and all crucifers.

If the disease occurs in the seed bed or greenhouse the soil should be sterilized by live steam in accordance with one of the methods referred to on page 10 or by treating the soil with a solution of formaldehyde (1 part of commercial formaldehyde to 100 parts of water) at the rate of 1 to 1½ gallons to every square yard of soil surface. When this latter method is used, about 10 days should elapse between the time of treating and of sowing the seed in order to allow the formaldehyde to evaporate from the soil. It is advisable to stir the soil occasionally during this time.

Distribution and loss.—Nematodes on different crops have been found widely distributed, but more especially in the tropical and subtropical climates. Their greater abundance in warm climates indicates that they are natives of the Tropics, and when found in the colder climates they have probably been introduced. The total loss caused by nematodes is very great, much more than is generally appreciated.

Cause.—Root-knot is caused by a parasitic eelworm (*Heterodera radicicola* (Greef) Müll.) one-twentieth to one-sixtieth of an inch in length. It penetrates the small roots and causes irregular swellings of various sizes. The nematode enters the roots in the larval stage. It then becomes motionless and gradually enlarges. After its entrance into the host changes take place, the male retaining the worm shape and the female becoming pear shaped. Each female lays several hundred eggs. Under favorable conditions a full life cycle can be completed in about four weeks. Nematodes migrate slowly in the soil, the distance covered in a single year probably not amounting to more than 1 or 2 yards. They are dependent upon foreign agencies for means of wide distribution. Nematodes probably pass the winter in the soil in the larval stage, though it is claimed that they winter in the roots of perennial plants in the mature stage. For a fuller discussion of this subject, see Bulletin 217 of the Bureau of Plant Industry, entitled "Root-Knot and Its Control."

BLACK-ROT (BROWN-ROT, STEM-ROT, DRY-ROT).

Description.—Of the symptoms of the black-rot Dr. Erwin F. Smith says:[1]

> The disease may appear in the plant at any stage of growth and is characterized by the following symptoms: Dwarfing, or one-sided growth of the heads, or, if the disease is very severe and has begun early in the season, by the entire absence of any head, and in extreme cases by the death of the plant. Occasionally the heads rot and fall off, but this is not a necessary consequence, the soft, bad-smelling rot being due to the entrance of other organisms. If the stumps of affected plants are broken or cut across, a brown or black ring will be observed, corresponding to the woody part of the stem, this part of the stem being especially subject to the disease. In bad cases this blackening may be easily traced upward into the center of the head and is generally worse on one side.

---

[1] Smith, Erwin F. The Black Rot of the Cabbage. Farmers' Bulletin 68, 1898, pp. 5–6.

Infection usually takes place at the margin of the leaf. The progress of the disease from the point of infection can frequently be traced through the veins of the leaf by the blackening of the bundles. The marginal infection is later followed by a browning and drying up of the infected areas of the leaf.

Control.—It is to be regretted that no sure methods for controlling black-rot are known, but the observance of certain precautions will prevent serious loss from this very destructive disease. (1) All seed should be disinfected before sowing, in accordance with the method described on page 9. (2) Care should be exercised in the preparation of the seed bed, and only manure and soil should be used that are known to be free from the disease. (3) Crop rotation, whether for the prevention of disease or not, is always a good practice. In connection with black-rot it is very important. To control the disease by this method the rotation should be one in which no cultivated crucifers or cruciferous weeds are allowed to grow in the ground for four or five years. (4) Insects slugs, snails, etc., by crawling from infected to noninfected plants carry black-rot organisms; when possible, they should be kept in subjection. (5) Live stock should not be allowed to roam at will over diseased cabbage patches, as they may carry the organisms to noninfected fields. (6) Diseased plants as soon as detected should be pulled up and destroyed and not thrown on the manure heap to compost.

Distribution and loss.—Black-rot has been reported from many States east of the Mississippi River and from a few west of it. For 20 years or more it has been destructive in the States of Ohio, Wisconsin, Michigan, and New York. In recent years several other States, particularly Virginia, Iowa, New Jersey, and Texas, have reported outbreaks. The disease has been injurious to cabbage as far south as Florida, and extends through all the States north into Canada. In 1908 it was reported from the State of Washington, but it has not occurred to our knowledge in any of the Rocky Mountain States with the exception of Colorado and Arizona. It is also well known in almost all parts of Europe and has been reported from the islands of Cuba, Porto Rico, and New Zealand.

The loss to cabbage and related plants from black-rot probably exceeds that of any one of the other diseases. It does not end in the field. It often happens that an apparently sound head is found to be rotten inside. The difficulty of detecting such heads and the fact that some are overlooked in handling result in placing many in storage, where they further decay.

Cause.—Black-rot is caused by a yellow bacterium (*Bacterium campestre* (Pammel) Erw. Sm.). Infection takes place through the leaves and occasionally through the roots. When infection takes place through the roots the organism spreads throughout the plant by following up the fibrovascular bundles of the stem (fig. 3). Probably most of the infections, however, take place at the margins of the leaves, either through punctures made by leaf-sucking insects or in the small droplets of water which collect at the margins of the leaves during cool nights and in damp, rainy weather. The organisms then find their way into the interior of the plant.

It is not positively known how the organisms get to the points of infection on the leaf, but presumably they are carried there on the bodies of insects or lodged on the leaf from the dust in the air. The progress of the disease from the point of infection is inward and downward. If follows the bundles of the leaf. The portion of the leaf around the point of infection, except the fibrovascular bundles, first turns yellow, then brown, and finally dries up. The veins of an infected leaf are black. Infection may take place at several points on the same leaf and on several leaves of the same plant. In the course of time the disease advances to the base of the leaf and enters the stem, from which point it may infect many other leaves and work up through the center of the head.

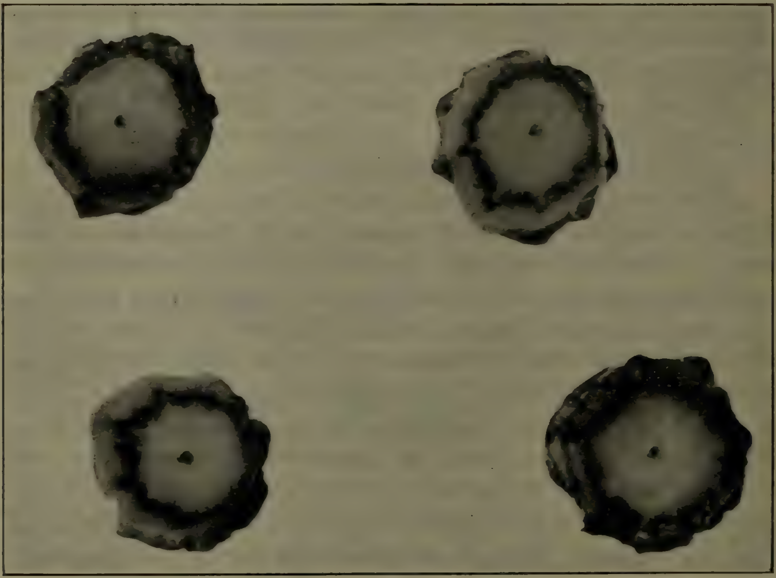


FIG. 3.—Sections through a cabbage stem showing the conspicuous ring of black bundles caused by the black-rot organism.

WILT (YELLOWS, YELLOW-SIDES).

Description.—So far as known cabbage is the only crop affected by the form of wilt known as "yellows" or "yellow-sides." The plants usually show the characteristic symptoms in about two to four weeks after they are set in the field, but often the disease appears early in their growth in the seed bed. The outer and lower leaves are the first to show the signs of the disease. The whole leaf may first turn yellow between the veins and around the margins, and then later brown, as if scorched, and finally drop off; or only one side of the leaf may dry up, while the other half remains normal. This latter symptom is the more usual and is a distinguishing characteristic of the disease; little or no wilting of the plant is then apparent and for that reason "yellows" is a better descriptive term than wilt. The lowest leaf is always the first to drop off, and this is followed by the next above, until only a bare stock is left, supporting a small imperfect head or none at all, depending upon the age of the plant when it became diseased (fig. 4).

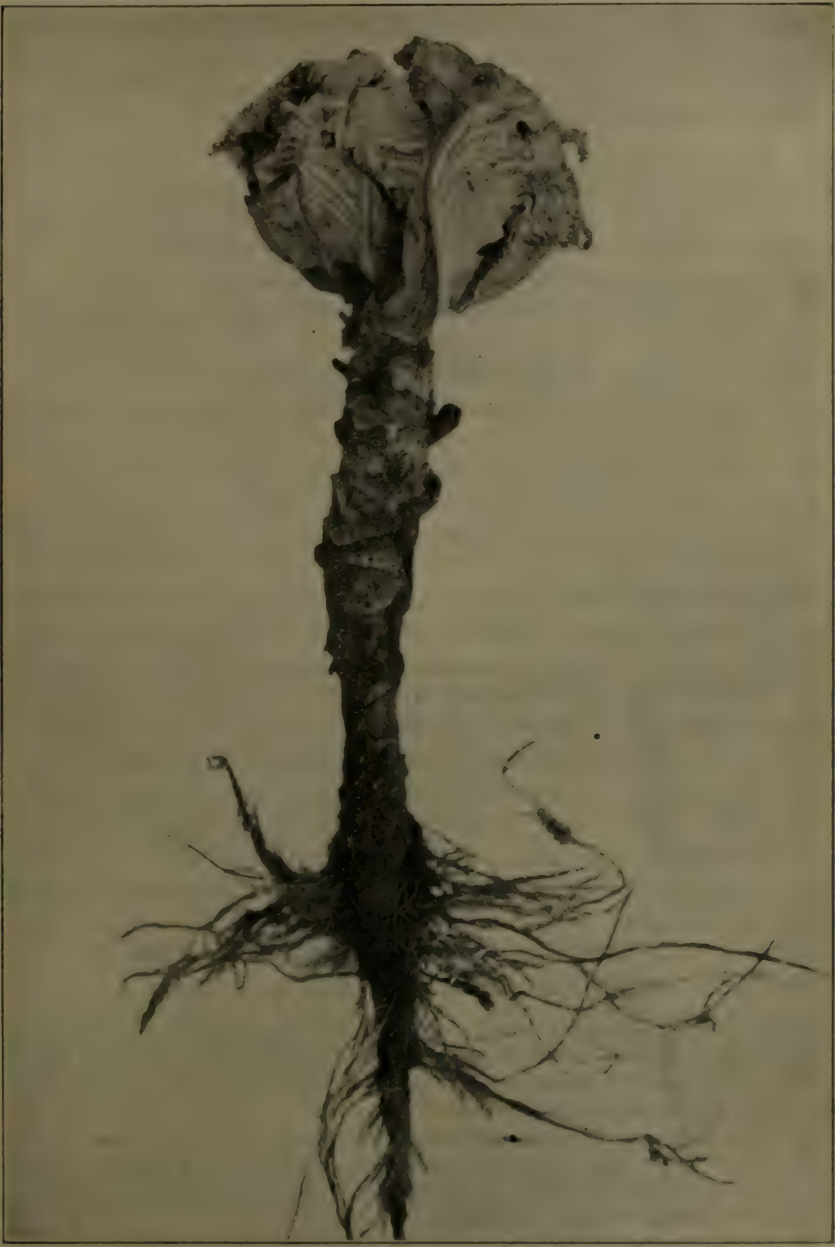


FIG 4. A cabbage plant showing the characteristic symptoms of wilt or yellows.

Subsequent to the dropping of the leaves short sprouts from one-half inch to 1½ inches long sometimes grow out between the leaf scars.

Browning of the woody portion of the stem is another characteristic of wilt, and if the stem is cut off with a sharp knife a black ring corresponding to the fibrovascular bundles may be seen.

Control.—The seed should be disinfected according to the method already described on page 9. Wilt has been found to occur in many seed beds, and for that reason manure and soil known to be free from the disease should be used. Sterilization of the seed bed should be practiced whenever possible. It has been found that even though the seed bed has been sterilized and noninfected plants obtained they may become diseased later if planted out in infected soil.

The plants evidently become diseased when quite young, and many can be detected before planting. Such should be pulled out and destroyed. Lessen the possibility of spreading the disease by destroying all diseased plants. Do not allow stock to roam at will over the fields. When water is used for setting it should be taken from wells instead of from drainage ditches, which are liable to be infected.

Crop rotation should be practiced. The organism causing wilt can live several years in the soil; hence, the rotation should cover a period of four to eight years.

Distribution and loss.—The organism causing wilt has been isolated from cabbage material received from the following States: North Carolina, South Carolina, Georgia, Mississippi, Maryland, Virginia, New York, Wisconsin, Ohio, and Michigan. It is possible that many cases of disease have been attributed to black-rot that in reality were due to wilt. The two diseases have often been found associated, and both organisms have frequently been isolated from the same plant.

Not until recent years has the loss from this disease been large in any one district, but serious results can be looked for in the future unless care is exercised to prevent its spread. The disease has been worse in Ohio than in any other State, the loss in one locality alone amounting to several thousand dollars annually. In Maryland and other States it has attracted some attention for several years.

Cause.—Wilt of cabbage is caused by a microscopic organism, Fusarium, the species of which has never been described. This group of fungi is only imperfectly known. Some are parasitic, while others are known to be only saprophytic, viz, organisms which live exclusively on dead vegetable matter.

Infection of the host undoubtedly takes place through the roots. Injuries to the roots made by insects may help to infect the plants, but such means are not necessary. The writer has caused the disease by inoculation of the soil in which the plants were growing, care being exercised not to injure the roots.

The vegetative part of the fungus consists of minute colorless threads called the mycelium. The fungus develops rapidly and after entering the roots grows up into the bundles of the stem, where it forms an almost impervious barrier to the water passing from the roots to the leaves.

Two forms of reproductive bodies are known: (1) The conidia, which are two to several celled and sickle shaped. They are not formed in the bundles of the host, but on the surface of the plant. A single spore under the microscope is colorless, but in mass they are pinkish. Often in culture media, and sometimes within the bundles of the host, small, oval, one-celled spores are developed. Such types of conidia are supposed to be developed only under abnormal conditions. (2) Clamydospores, whose bodies are roundish, thick walled, and able to stand severe and changeable weather. They are formed on the end of a hypha, or as a swelling of the mycelium on the surface of the host, or in the soil.

It is probable that this fungus, like many others of the same form, can live as a saprophyte, but has adapted itself to parasitic habits. If such is the case it can live on decayed vegetation in the soil until it comes in contact with a suitable host.

Closely related species of Fusarium cause numerous diseases of other crops. Among those well known and commonly met with are the dry-rot of potatoes, the scab of wheat, and the wilt of flax, cotton, and cowpeas. Tomatoes are also affected with a similar fungus as yet undescribed.

Differences between most of these diseases are established only after cross inoculations involving extensive cultural work. The cabbage-wilt fungus has not been inoculated into other plants, so that it is not known whether this species of Fusarium causes diseases of other crops.

BLACK-LEG (FOOT-ROT, WILT).

Description.—So far as known black-leg occurs only on cabbage and cauliflower and may attack the plants at any time in their growth, but more commonly when young. The earliest symptoms are usually seen in the seed beds two or three weeks before the time to set the plants in the field.

Infection frequently takes place on the stem at the surface of the ground just below the attachment of the leaves where lesions, abrasions, or sunken areas irregular in outline occur on the epidermis or it may take place at the margin of the leaves at the end of the larger veins, probably by means of the droplets of water that collect there during the night or in damp weather. Sunken spots or abrasions frequently occur also on the petiole of the leaf or on the midrib. At Norfolk, Va., where this disease caused heavy loss to the cabbage crop during the spring of 1911, infection through the leaf was very common. This mode of infection was less common in other districts where the disease has been observed. Insects were found associated to some extent with black-leg in Virginia, and the writer is inclined to believe that they assist in its spread. Numerous diseased plants, however, were found which showed no evidence of insect injury. The disease spreads from the point where the stem is infected downward to the roots and around the stem, often completely girdling it. If the plant is pulled up the small fibrous roots will be found more or less completely killed, and in advanced cases all the lateral roots will have rotted off. Before the death of the plant takes place a purplish tint is developed in the foliage which persists until the plant dies. This coloration constitutes one of the principal symptoms of the disease.

Numerous minute black specks (pycnidia) a little larger than a pin point may be found scattered indiscriminately on the stem and leaves, in and about the lesions or abrasions caused by the black-leg fungus. (See fig. 5.) The pycnidia are filled with myriads of spores which serve to disseminate the disease.

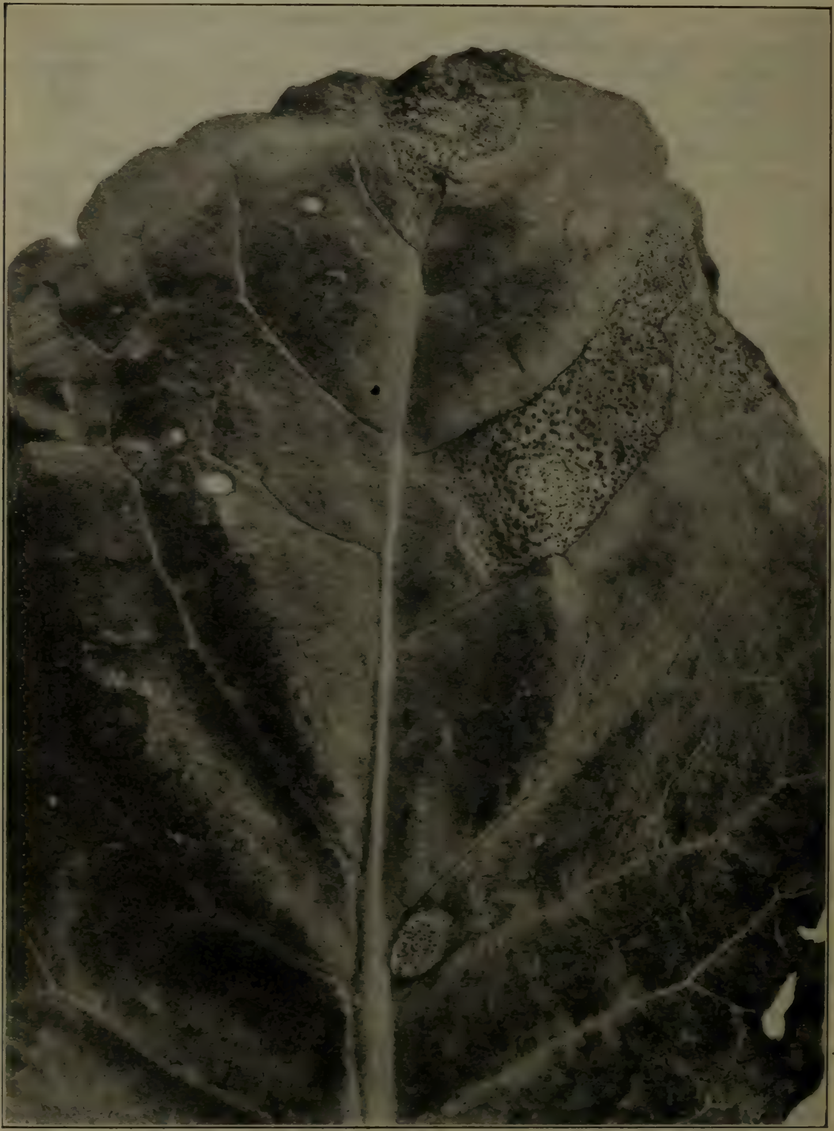


FIG. 5.—A cabbage leaf showing injury from the black-leg organism.

Wilting of the whole plant is very characteristic of black-leg of cabbage. The leaves, instead of falling off, adhere to the stem and droop down as though suffering for water.

Control.—Cabbage black-leg is harbored for the most part in the soil on the decayed stems and leaves of the plants. In view of this fact the seed bed should not be located on land where the disease has occurred. The methods of controlling black-leg adopted should be those of prevention rather than cure. After selecting a suitable place for the seed bed, manure should be obtained from some source where cabbage stems and leaves have not been thrown to compost, since they are often a source of infection. The Ohio Agricultural Experiment Station has studied this disease in that State and recommends treating the seed beds with Bordeaux mixture (4-4-50 formula) at the rate of one gallon per 10 square feet, just after sowing the seed. A second treatment should be given two weeks before and a third just preceding the setting of the plants in the field. It is claimed by the Ohio station that this method of treatment will keep the disease down in the seed bed and prevent its appearance in the field.

The prevention of black-leg in the seed bed is of the greatest importance in restricting its spread. However, many fields in some localities are already infected, and the disease can be eradicated from them only by care and perseverance. All diseased plants should be burned. Cattle, horses, and other stock should not be allowed to roam from diseased patches into noninfected fields. Crop rotation should be practiced, and the seed should be disinfected in accordance with the formula given on page 9.

The writer's own experience has shown that steam sterilization of the soil for one hour at a temperature of 212° F. will prevent the disease in the seed bed.

Distribution and loss.—Cabbage black-leg occurs in Holland, France, and South Australia. It is not known to be widely distributed in this country, but was found on cabbage in 1910 in the States of Ohio, Michigan, and Iowa and occurred abundantly in Virginia during the spring of 1911. It was reported in 1911 on cabbage from Wisconsin and New York and on cauliflower from Louisiana. It probably also occurs in other States.

The loss occasioned by black-leg varies greatly in different localities and in different fields. The writer saw fields in Ohio where 60 per cent of the crop was destroyed by this disease alone and others where the loss would not exceed 5 per cent. (See fig. 6.) It was found in fields where cabbage had never before been grown, while some old fields had comparatively little of the disease. Only a few cases were found in Michigan, and the loss from the trouble was negligible. In Iowa it was quite prevalent in certain sections, and the loss was considerable. The disease was found to be more destructive in the trucking sections of tidewater Virginia than in any of the other States. It was so severe that in a few fields no marketable cabbage was cut; in some the loss amounted to as much as 75 per cent of the crop, while in others the disease did not occur.

Cause.—Black-leg is caused by a fungus (*Phoma oleracea* Sacc.).

Infection takes place on the stem near the ground, probably in wounds made by insects, and spreads from that point around the stem, down into the roots, and up to the leaves. Leaf infections also occur at the margins, generally at the ends of the larger veins.

The fruiting bodies of the fungus appear as black specks (pycnidia) in the lesions and abrasions. In the pycnidia are formed myriads of microscopic one-celled spores which upon oozing out are exposed to the winds, insects, and other foreign agencies, by which means they are probably carried to other plants. Wet weather is favorable for the spread of the disease, the greatest loss being occasioned during a wet season.

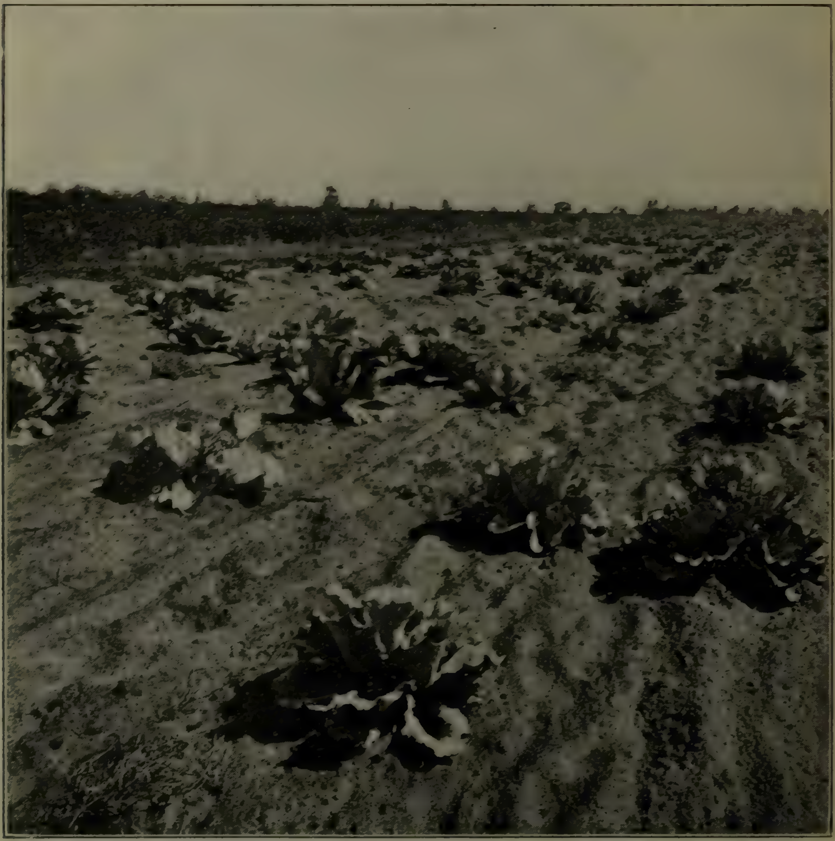


FIG. 6.—A field of cabbage with 75 per cent of the plants killed by the black-leg fungus.

In Australia cauliflower is injured severely by the same disease. The writer has not seen cauliflower attacked in the field by this organism, but has produced the disease in the greenhouse with ease by means of artificial inoculations.

SOFT-ROT.

Description.—Soft-rot of crucifers is characterized by a soft, mushy, almost slimy decay, which after entering, generally at the crown or root tip, spreads rapidly throughout the whole plant. The soft-rot bacteria as a class are marked by their ability to destroy plants very quickly under favorable temperature conditions. They seldom affect uninjured plants, but require a wound or other injury to gain a foothold. Infection takes place in the field, where considerable damage has been occasioned, but the greatest destruction to this crop is caused in the cabbage storage houses. Under improper storage conditions the disease spreads rapidly, frequently covering all the outer leaves. The slime formed under these conditions is very unsightly and consequently affects the market value, even though only slight injury is caused.

Control.—Fields where the disease is known to occur should be avoided and rotation practiced with crops not injured by soft-rot organisms. It has been found that in the storage house, where the maximum loss occurs, an increase of the temperature much above the freezing point and a high percentage of humidity will result in rapid decay. In view of this fact it is advisable that a temperature should be maintained uniformly 1 or 2 degrees above freezing and the relative humidity kept near that of the outdoor air by careful ventilation. Furthermore, cabbage and other crops when going into storage should be handled carefully, so that they will be injured as little as possible. Since the soft-rot organisms are especially sensitive to light and drying, the crop should be thoroughly dried in the sunshine before being put into storage.

Distribution and loss.—The loss from soft-rot is considerable, especially in storage houses, where 25 to 50 per cent or more of the crop has been destroyed in a single season. The greatest loss occurs in New York and Wisconsin, where the storage of cabbage forms an important industry.

Cause.—Soft-rot of various crops is due to a group of closely related bacteria. *Bacillus carotovorous*, named and studied by Prof. L. R. Jones at the Vermont Agricultural Experiment Station, was found to affect a wide range of plants, such as turnips, onions, celery, radishes, carrots, and tomatoes. Mr. F. C. Harrison, of the Ontario Agricultural Experiment Station, Guelph, Canada, found a soft-rot organism destroying cauliflower, cabbage, and turnips, and called it *Bacillus oleracea*.

MALNUTRITION, A PHYSIOLOGICAL DISEASE.

Malnutrition is a trouble which affects cabbage, cauliflower, and other crops, especially in the Southern States. It is quite different from any of the diseases previously discussed, all of which are caused by parasites. By malnutrition is meant a disturbance of the normal functions of a plant which may be a result of its inability to obtain the proper nutrient substances from the soil. Malnutrition may be caused in several ways, such as the use of excessive mineral fertilizers, lack of humus, accumulation of acids in the soil, and the lack of nitrifying organisms.

Description.—The most characteristic symptom of malnutrition is a change of the normal green of the leaves to a light green or yellow between the veins and around the margins. (See fig. 7.) The lower leaves are the first to show symptoms, then the upper and inner ones. All diseased leaves are perceptibly thickened and so brittle as to be easily crushed between the fingers.

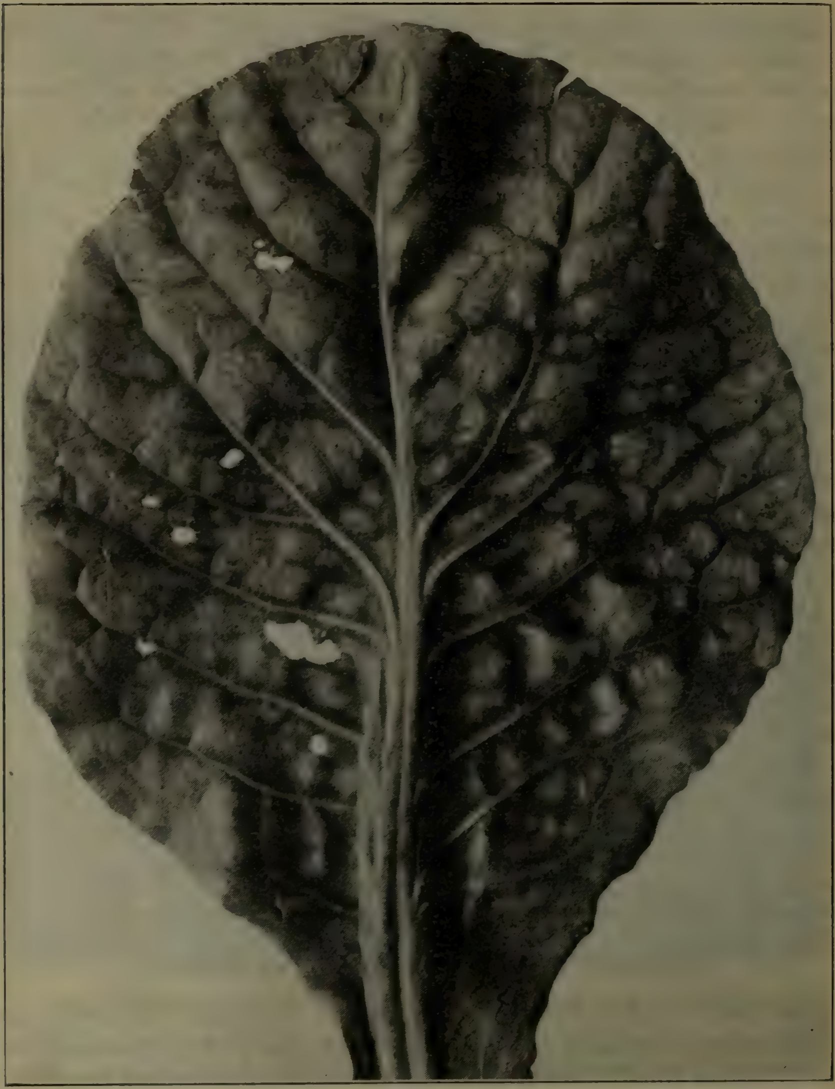


FIG. 7.—A cabbage leaf showing the characteristic symptoms of malnutrition.

The heads from plants slightly affected are small and immature; when plants are badly diseased no heads are formed.

The roots are small and the lateral feeders few in number and frequently dead at the extreme end. Often the epidermis of the stem at the surface of the soil is injured, closely resembling the corrosive action of some acids and alkalies.

Control.—In controlling malnutrition four points need consideration: (1) Limitation of the quantity of fertilizers used; (2) adjustment of the composition of the fertilizer to meet the crop requirements; (3) the rational use of lime; and (4) the maintenance of the organic matter of the soil.

Practice on the part of farmers tends to increase the quantity of fertilizers when the preceding crop was poor, in the belief that the yield can in this way be maintained. This practice is not always the best. As a result of the writer's experiments on early cabbage in Virginia covering a period of three years, it was shown that better yields could be obtained from 1,000 pounds per acre of mineral fertilizer than from any larger amount up to 4,500 pounds, which gave the smallest yield of all. For the cabbage crop this is a saving of about 1 ton of fertilizer per acre, representing a value of about $35.

The composition of the fertilizer or the ratio of the different substances composing it is likewise very important in connection with malnutrition diseases. Where maladies of this sort occur, a fertilizer for cabbage and cauliflower should be derived from sources that will give an alkaline rather than an acid reaction. It has been found that an acid soil is likely to cause the disease and that these crops have been restored to a normal condition when lime was added. For a fertilizer which will meet the above requirement the nitrogen should be derived from nitrate of soda, fish scrap, or dried blood; the phosphorus from bone or Thomas slag; and the potash from the sulphate or carbonate of potash and not from the muriate.

Lime is not ordinarily needed as a plant food. It is used merely as a soil corrective. In the Southern States where mineral fertilizers are extensively used, the soils are very deficient in lime. Some of these soils are so acid as to require 15,000 pounds of slaked lime per acre to neutralize them to the depth of 1 foot. Scarcely any long-cultivated fields have been found to require less than 3,000 to 5,000 pounds. Even on the soils requiring the lesser quantities of lime, crops would not grow vigorously, and in the most acid soil the yields are greatly reduced and the plants injured in various ways. The full lime requirements need not be satisfied. Experiments have shown that the yield of cabbage can be increased several times by the addition of only 1,000 to 2,000 pounds of lime on soils requiring 8,000 pounds per acre to neutralize them as compared with other parts of the same field similarly fertilized but unlimed. While the striking increase in yield is probably due to a large extent directly to a neutralization of the acid in the soil, lime serves other purposes. Among the other more important effects of liming soil the following may be mentioned: (1) To render available certain forms of plant food, especially compounds containing potassium; (2) to facilitate the decomposition of organic matter by encouraging the growth of micro-organisms; (3) to promote the growth of organisms that gather nitrogen from the air; and (4) to improve the physical texture of the soil.

The old cultivated fields of the South at the present time are ordinarily deficient in humus or organic matter, a condition for which mineral fertilizers are largely responsible. The yields from the use of fertilizers were so satisfactory for a long time that the farmer came to believe that this was all that was necessary to produce crops. In view of this fact the organic matter of the soil was disregarded, and it gradually became exhausted, so that at the present time fields that contain 0.50 per cent or less of humus are not uncommon, while 3 to 5 per cent should be present.

It is now found necessary to restore humus before fair yields can be expected. Humus can be supplied by the use of stable manure or by growing green-manure crops such as cowpeas, soy beans, vetches, etc., to be turned under when mature. The results from this method of restoring natural fertility to the soil are ordinarily very marked on the first succeeding crop.

Distribution and loss.—Malnutrition diseases are confined principally to those localities where mineral fertilizers are used for the production of larger and earlier crops. The disease, therefore, is restricted mostly to the Southern States. In general these soils are poor, respond quickly to fertilizers, and have been intensively and carelessly farmed for many years. The loss from this trouble, though large, can not be accurately estimated.

Cause.—Constant, clean cultivation for many years has robbed the soil of most of its original fertility. The farmers, therefore, naturally turned to the use of commercial fertilizers as a substitute. The results for many years were very gratifying. At the outset better crops were obtained than was possible on the best soils without fertilizers. This led the farmers to believe that fertilizers alone were necessary on any soil and the more used the greater the yield. When the returns gradually decreased as a result of this practice the quantity applied was gradually increased until it was not uncommon to add as much as 3,000 pounds of mineral fertilizers per acre for a single crop of cabbage. A large part of the fertilizer applied was not used by the plants, but remained in the soil where in the course of a number of years a considerable quantity accumulated.

It is a well-known fact that the salts comprising mineral fertilizers are poisonous to plants when used in excessive quantities. Some fertilizers have an acid reaction and eventually cause what is popularly known as a "sour soil." On the other hand, a small quantity of acid in the soil is not generally injurious, but it is not uncommon to find soil in the South so acid as to require 5,000 to 9,000 or more pounds of lime per acre to neutralize it. No agricultural plants will give their best yield under such conditions.

During the years when mineral fertilizers gave good results no attention was paid to maintaining the humus in the soil; consequently it soon became exhausted. In the presence of a large quantity of acid accumulated in the soil from the use of mineral fertilizers and the absence of humus the nitrifying bacteria and other beneficial organisms could not thrive. If legumes were planted no nitrogen was gathered from the air, and what vegetative matter was left on the ground remained in an undecayed state. A bacteriological examination of some of these soils has shown that the beneficial organisms are wanting or lacking in power to act. The addition of larger quantities of mineral fertilizers did no good but rather increased the loss, the plants being in a state of starvation even in the presence of abundant food.

Briefly summarized, malnutrition in truck crops is caused by the excessive use of mineral fertilizers and the absence of humus and of nitrifying bacteria.

DOWNY MILDEW.

Description.—Downy mildew first appears in the spring as a whitish mold in isolated spots on the under sides of the leaves. It may also occur on the stems. At the close of the season the portion of the leaf immediately surrounding the diseased area appears yellow and later turns brown and dries up. Frequently, light areas are observed in the center of a dark ring, which in turn is surrounded by a light or yellow area, thus presenting a conspicuous mottled appearance.

Control.—Downy mildew is seldom so troublesome as to require remedial measures, but when treatment is necessary it should be observed that all cruciferous weeds are attacked by this organism. Such weeds are sources of infection to cabbage and related crops and should be kept down. Any plants found diseased in the seed bed should be destroyed, not planted. The remains from diseased plants should be destroyed, as they serve to carry the resting spores over the winter. Crop rotation should be practiced. The plants should not be grown too thick, nor kept too wet in the seed bed. The plants in the seed bed should be sprayed about once a week with Bordeaux mixture (4–4–50 formula).

Distribution and loss.—Downy mildew seldom causes any serious loss except in seed beds. It has been found in Australia and Europe and has been reported from several States in the United States. It undoubtedly occurs wherever cabbage is grown, but owing to the fact that it causes but little loss to the crops it has not been reported.

Cause.—Downy mildew (*Peronospora parasitica* (Pers.) De By.) attacks all crucifers and causes distortions and abnormal growth. Two forms of spores or reproductive bodies are formed. The asexual spore is borne in the air on the end of branched conidiophores. The spores or reproductive bodies, when germinating, send out hyphæ which enter the stomata (breathing pores) of the host. The mycelium, or vegetative portion of the fungus, lives entirely within the host. The spores are formed in great numbers and are readily carried from one host to another by a gentle breeze or by insects. The disease is carried over the winter by means of yellowish, thick-walled, resting spores which are able to withstand unfavorable conditions until spring, when they germinate and reestablish the disease.

WHITE-RUST.

Young plants are more subject to attack, but the damage to cruciferous crops from white-rust is ordinarily very slight. The disease may occur on any part of the plant above ground, but more frequently on the leaves, where the tissue is often stimulated to distorted and abnormal growth. Moist, cloudy weather furnishes suitable conditions for the spread and growth of this disease.

Control.—Control measures are rarely necessary; if required, spray the plants in the seed bed once each week with Bordeaux mixture (4–4–50 formula). The seed bed should not be kept too moist. Set only healthy plants in the fields and destroy all others.

Distribution.—White-rust is distributed throughout the world and attacks all crucifers.

Cause.—The disease is caused by a fungus (*Albugo candida* (Pers.) Ktz.) which enters the tissue of the host through the stomata, or breathing pores. Small oval spores are formed which are attached one to another in a beadlike manner under the epidermis. They finally escape by a rupture of the epidermis and are then easily wafted by the wind or carried on the body of insects to other plants. In the presence of sufficient moisture they readily germinate, the hyphæ finding their way into the stomata, or breathing pores, if lodged on the proper host. The disease is carried through the winter by the formation of thick-walled resting spores within the tissue of the host, from which they are set free the following spring by the decay of the plant.

SPOT DISEASE OF CAULIFLOWER.

This spot disease was first found to attack the leaves of cauliflower, but later was observed on cabbage to a more limited extent. It causes on the lower surface of the leaf, and less abundantly on the upper, small brownish to purplish gray spots somewhat irregular in outline. A puckering of the leaf results when the midrib and larger veins are badly affected.

Some loss was caused to cauliflower in tidewater Virginia during the spring of 1911, where 25 to 90 per cent of the plants in the worst cases were attacked.

This is a new disease of cauliflower and cabbage, due to a bacterium, as determined by Miss Lucia McCulloch, of the Bureau of Plant Industry, and no means for its control have been worked out. It has been observed that the spot disease is most severe during cool, damp weather, and is held in check when the warm, sunny days of late spring come on. In view of the fact that the organism is especially sensitive to sunshine and warm weather it is not likely to cause any serious damage except during protracted rainy, cool weather. Crop rotation should be employed in controlling it. So far as known the organism causing the spot disease of cauliflower and cabbage does not attack any other crucifers.

LEAF-BLIGHT (BLACK MOLD).

Description.—Leaf-blight is due to the fungus *Alternaria brassicae* (Berk.) Sacc., which may attack the plant at any stage of its growth. The vegetative part of the fungus lives in the leaf tissue of the host and under field conditions forms roundish black spots marked with concentric brown zones. These spots vary from one-fourth to one-half of an inch or more in diameter. The fungus may also live as a saprophyte and causes considerable damage to cabbage in the storage houses.

Control.—To prevent loss from this fungus in the storage house the following suggestions should be observed: (1) Disinfect the storage house by spraying the walls, benches, and bins with Bordeaux mixture; (2) exercise care in handling, so as to minimize injury to the heads; (3) maintain a temperature 1 or 2 degrees above freezing; and (4) keep the humidity as low as possible by proper ventilation of the house with outside air.

Distribution and loss.—Leaf-blight causes considerable damage to cabbage and collards in this country and in Europe. The greatest loss to cabbage occurs in the storage houses. The organism causing the disease is present in the houses under ordinary conditions, or it may be carried there with the cabbage when it goes into storage. It gains access to the tissue through wounds made by handling and cutting or by following up the tissue killed by other organisms. In the presence of plenty of moisture and a suitable temperature it develops rapidly, forming an unsightly black mold over the heads.

POWDERY MILDEW.

Powdery mildew is caused by a parasitic fungus (*Erysiphe polygoni* DC.) which forms a white powdery dust on the leaves of turnips and a few other plants. The loss caused by this disease is so slight that treatment is unnecessary.

DAMPING-OFF.

Damping-off is a disease of young seedlings and may be caused by any one of several species of fungi. It occurs mostly in the seed bed, where plants are growing in a crowded condition. It is rarely found in the open field. It is also a common disease in greenhouses, where a relatively high humidity is maintained and where the plants are protected from sunshine and free circulation of the air. The disease usually attacks the seedling on the stem at the surface of the soil soon after it comes through the ground. It soon girdles the stem and destroys the epidermis. The plant finally topples over and dies.

Preventive rather than curative measures should be employed for this disease. If damping-off has occurred before, the soil should not be used again, or if used should be sterilized according to one of the methods already discussed. Any method that will prevent the accumulation of too much moisture in the surface soil and reduce the relative humidity of the air about the plants is advantageous in preventing damping-off. This can be accomplished by practicing the following suggestions: (1) The upper layer of soil should be frequently stirred; (2) a free circulation of air about the plants and exposure to sunshine should be permitted; (3) the plants should be watered in the morning in preference to the late afternoon or evening; and (4) a layer of fine, heated sand should be sprinkled over the surface of the soil.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

○

Issued April 9, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 489.

TWO DANGEROUS IMPORTED PLANT DISEASES.

BY

PERLEY SPAULDING,
Pathologist, Investigations in Forest Pathology,

AND

ETHEL C. FIELD,
Scientific Assistant, Cotton and Truck Disease and Sugar-Plant Investigations, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 30, 1912.

Sir: I have the honor to transmit for publication a paper showing the imminent danger to American agriculture and forestry from two foreign fungous plant diseases which are transmitted in imported plant material. These two diseases, the one threatening the successful future of one of our most valuable forest trees and the other apparently one of the worst enemies of our great food crop, the potato, have already reached North America. The former has been widely distributed in this country but has not become established, while the latter has not yet been found in the United States. Neither in certain stages can be detected by inspection, and the only method of preventing their ultimate permanent establishment in the United States is national control of importations of the host plants. The danger from such diseases is continual and is increasing with the extension of rapid transportation facilities. National control of importations of plant material is necessary for adequate and prompt action in such emergencies as the present one, which are certain to recur more or less frequently.

The lack of national power and of adequate State laws makes necessary the prompt and wide distribution of these accounts of the white-pine blister rust and the potato wart disease.

I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
The white-pine blister rust 5
  Life history of the white-pine blister rust 6
  Economic importance of the disease 6
  Plants affected by the white-pine blister rust 9
  Field characters of the disease 10
  Distribution of the white-pine blister rust 12
  Source of diseased white-pine stock found in America 12
  The situation in America 12
  Methods of combating the disease 13
  Practical suggestions regarding the white-pine blister rust 15
    Danger to all American five-leaved pines 15
    The disease expected to be worse in America than in Europe 15
    Estimates of possible damage 16
    Actual cost of imported white-pine stock 16
    Why inspection for this disease is inefficient 17
    Why no nursery can be given a clean bill of health 17
    Prevention always easier and cheaper than cure 18
    The work of eradication must be done by the States 18
    Caution to general nurserymen 18
    National power needed 19
The wart disease of the potato 19
  Description of the wart disease 20
  Life history of the wart organism 21
  Means of distribution of the wart disease 22
  Control of the wart disease 23
  Distribution of the wart disease 23
  Damage in England 24
  Means of exclusion 24
Present method of inspection for insects entirely inadequate when applied to fungous plant diseases 26
Summary 29

ILLUSTRATIONS.

Page.
Fig. 1. Young white-pine tree with swelling caused by blister rust 7
2. Potato wart 20
3. Potatoes cut in half, showing the wart disease 21

B. P. I.—725.

TWO DANGEROUS IMPORTED PLANT DISEASES.

INTRODUCTION.

Within the past few years two very serious European plant diseases have been brought to North America upon imported plant material. These diseases are of more than ordinary economic importance to us, as one is apparently the worst enemy of the white pine in Europe, while the other is practically certain to become one of the worst enemies of the potato wherever it occurs. They are especially serious because both have stages of development in which they can not be detected by inspection. The white-pine blister rust has been brought to this country in several million young white-pine trees, some of which are known to have been in the country a number of years before the presence of the disease became known. The importations already made have been carefully inspected and the diseased trees removed so far as possible. So far as now known the disease has not yet spread and become established here. The continued irresponsible importation of diseased white-pine trees renders it imperative that importation be regulated to some extent. The fact that neither disease can be detected by inspectors except in its most evident stages of development seems to make necessary some national quarantine power over plant material similar to that now in force for animals.

THE WHITE-PINE BLISTER RUST.

The white-pine blister rust (*Peridermium strobi* Klebahn) recently extensively brought into America is a fungus which is native in Europe. It first occurred there upon the stone pine (*Pinus cembra* L.), which is also a native of Europe. The fungus belongs to the rusts, of which the wheat rust is a well-known representative. Like the wheat rust, the white-pine blister rust has two entirely different hosts. These are the five-leaved pines for one stage of growth and currants and gooseberries (*Ribes* spp.) for the other stage. The two stages went by different names and for a long time were supposed to be two distinct fungi, but experiments have shown that the one when sown on its proper host plant will produce the other, and vice versa.

NOTE.—A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.

LIFE HISTORY OF THE WHITE-PINE BLISTER RUST.

The life cycle of the blister rust is as follows: The winter spores are blown from the currant and gooseberry leaves upon which they are produced to various parts of the white pines in the vicinity. There they stick to the bark of the young trees or branches and germinate. The branching threads of the fungus penetrate the inner bark tissues for some distance, but cause no external sign of disease until nearly a year after the time of infection. This period of incubation, so called, varies from one to several years, after which time the bark tissues commence to thicken perceptibly, giving the first visible signs of the disease. This thickening progresses rather rapidly for a few months until the bark is several times its normal thickness. The swelling is usually of a spindle shape, commonly tapering upward, but also in the reverse direction in some cases (fig. 1). Sometimes the swelling extends the length of an entire year's growth. In such cases wartlike bunches are scattered over the swollen part, the entire diseased portion having a peculiar obese apearance. Early in the spring, after the swelling has become noticeable, the fruiting bodies are formed in one or more places, bursting forth from the inner bark tissues and setting free the yellow spring spores. This is the most conspicuous stage in the disease, but lasts only from the middle of April to the middle of June. During this time the inspection of diseased trees should be made. These spring spores are blown about and fall upon the newly developed leaves of any currants or gooseberries that may be in the vicinity. Here they germinate and infect the leaves. In 12 days or more new fruits are formed in tiny orange pustules which break forth on the lower side of the diseased leaves. The summer spores therein produced in turn infect other currant and gooseberry leaves, producing more summer spores in about two weeks' time. Thus the disease spreads rapidly on the currant or gooseberry leaves. After a month and a half or longer, slender hornlike outgrowths are produced in some of the pustules. These in turn produce the winter spores, which are capable of infecting young white-pine stems and branches.

ECONOMIC IMPORTANCE OF THE DISEASE.

The stage of the disease upon currants and gooseberries is usually the most abundant and conspicuous, but the actual damage is not great. Badly diseased leaves are shed prematurely and the bush is more or less weakened. Instances are known where the bushes have died from the effects of the disease, but this is not common. The fungus is not known to live over winter on Ribes, but its occurrence in some cases seems to indicate that it may attack bud scales or young twigs and possibly be shipped thus on dormant cuttings from one country to another.

The stage on pines is the one in which the greater damage is done. The fungus lives in the bark of the host, forming new fruits each spring until the tree dies. It is sure to kill the affected trees, since if the tree survives until it is 25 to 30 years old it is relatively weak at the point of attack and ultimately breaks over in some heavy wind Most of the attacked trees die the first season that the fungus fruits. However, there may be a small number which survive until the next spring and bear a new crop of spores. Each year the number decreases

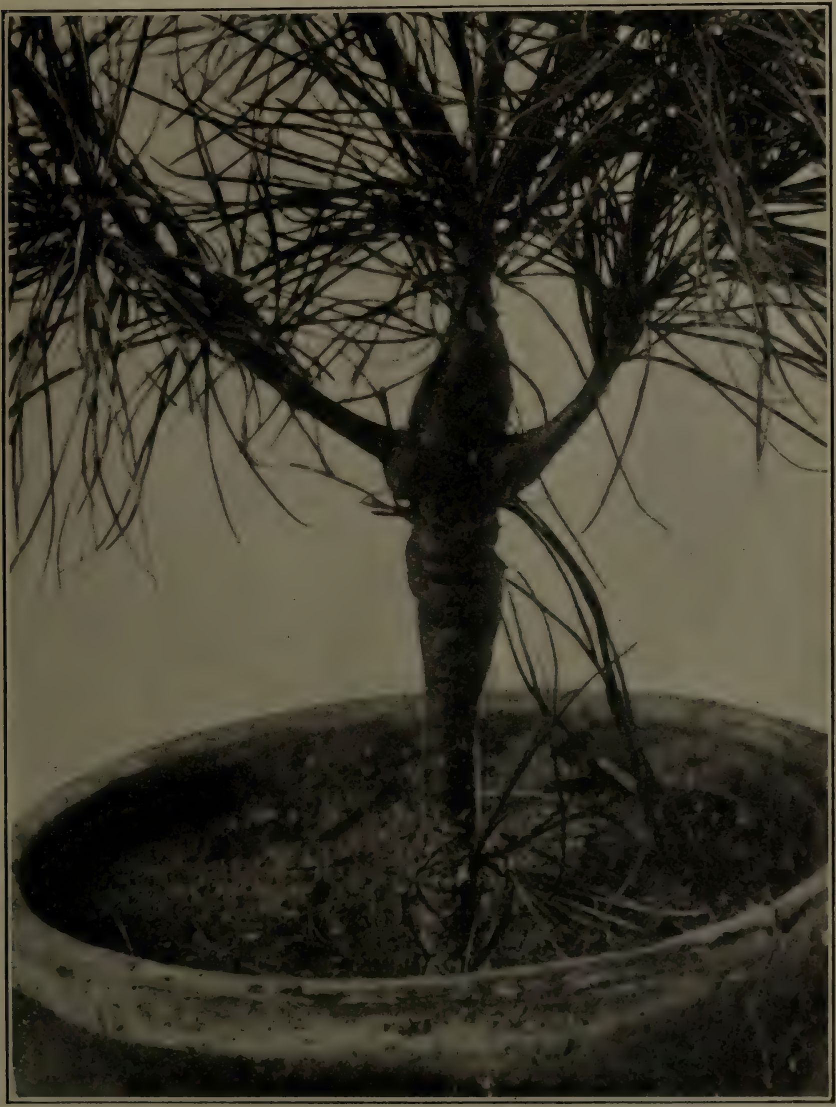


FIG. 1.—Young white-pine tree with swelling caused by blister rust.

until the disease finally dies out *if there are no Ribes near enough to become affected.* The great damage is caused by the dying of the young pine trees in nurseries, plantations, and parks and those naturally reproduced in the forests. Old trees may be attacked, but only on their younger twigs and branches. Trees 100 years old have been killed, but such cases are not common. The use of white pine has been discontinued in Denmark and Holland and is largely given up in England because of this disease. In Europe the loss has in numerous cases ranged from 15 to 100 per cent of the original stand.

Many more or less definite statements have been found of the occurrence of this fungus in European nurseries, but in most cases the nursery is not definitely named. The following German nurseries have had the disease at approximately the indicated dates: J. Heins's Sons, Halstenbek, 1903–1911; Späth, Berlin, 1887–1895; H. C. A. Helleman, Moorende (near Lilienthal), 1886–1887; Metz & Co., Steglitz (near Berlin), 1887–1889); H. H. Pein, Halstenbek, 1905–1907. The French firms of Levavasseur & Son, Ussy, Barbier & Co., Orleans, and E. T. Dickinson, Chatenay, have recently shipped diseased trees into this country. Less definite statements show that the disease has occurred in nurseries at the following places: *Germany:* Berlin, Muskau, Eberswalde, Amelsbüren, Delmenhorst, Tharandt, and Mühlenbek. *France:* Paris. *Sweden:* Stockholm. *Russia:* St. Petersburg.

Neger and Von Tubeuf mention this disease as the most destructive one occurring upon white pine in Germany. Griffon and Maublanc state that it caused much damage in 1908 in the forest of Fontenoy, France, and Pechon also mentions it as destructive in the forests of Ardennes, France. Ritzema Bos states that the disease has become so prevalent in Holland that the culture of white pine has been given up. A few years ago discrimination was shown in Europe against white-pine stock raised in Halstenbek, Germany, because of the blister rust. Ravn has recently stated that this disease alone is responsible for discontinuing the use of white pine in Denmark as a forest tree, as the tree is otherwise very successful there. Somerville says "that the outlook in this country [England] for the Weymouth (white) and other five-leaved American pines is almost hopeless. * * * But it is to be feared that the day is not far distant when it [the white-pine blister rust] will gain a footing in North America, and if it spreads there, as it has done in Europe, the loss that will result through the destruction of one of America's most valuable lumber trees can only be described as appalling."

Many other statements regarding the serious nature of this disease will be found in Bulletin 206 of the Bureau of Plant Industry, entitled "The Blister Rust of White Pine."

PLANTS AFFECTED BY THE WHITE-PINE BLISTER RUST.

The fungus which causes the white-pine blister rust is not limited to a single host species in either stage. In the spring form (*Peridermium strobi*) upon pines it evidently first occurred native in the Ural Mountains and Alps upon the European stone pine (*Pinus cembra* L.). About 200 years ago the white pine (*Pinus strobus*) was introduced from America into Europe and within the last century has been extensively planted in European forests. About 50 years ago the blister rust was found attacking the white pine in Europe. Since that time the disease has been found in Europe also upon the sugar pine (*Pinus lambertiana* Douglas), the western white pine (*P. monticola* Douglas), and probably the Himalayan white pine (*P. excelsa* Wall.). All these host pines are very closely related to each other and all belong to the five-leaved group. There are 18 different five-leaved species, which are found in different regions of the world. Of these 18 species which are liable to attack, North America has exactly one-half, or 9 species. The following table gives these species, with their native ranges:

THE NORTH AMERICAN FIVE-LEAVED PINES.

Common name.	Scientific name.	Range.
1. Mexican white pine	*Pinus ayacahuite* Ehrenb.	Southern Mexico into Guatemala.
2. Hook pine	*P. strobiformis* Engelm.	Southern Arizona into Chihuahua, Mexico.
3. Limber pine	*P. flexilis* James	Rocky Mountain region.
4. White-bark pine	*P. albicaulis* Engelm.	British Columbia, Alberta, and Montana to Wyoming, Washington, Oregon, and southern California.
5. Foxtail pine	*P. balfouriana* Murray	California.
6. Bristle-cone pine	*P. aristata* Engelm.	High peaks from Colorado to southern Utah, Nevada, southern California, and northern Arizona.
7. White pine	*P. strobus* L.	Newfoundland to Pennsylvania, along the Appalachians to Georgia, west to eastern Iowa and Minnesota; in Canada from Lake Winnipeg to the northern shore of St. Lawrence Gulf and Newfoundland.
8. Western white pine	*P. monticola* Douglas	Montana and southern British Columbia to Washington, Oregon, and California.
9. Sugar pine	*P. lambertiana* Douglas	Oregon through California to Lower California, Mexico.

THE FOREIGN FIVE-LEAVED PINES.

Common name.	Scientific name.	Range.
10. Himalayan white pine	*Pinus excelsa* Wall	Himalaya Mountain region.
11. Roumelian white pine	*P. peuce* Gris	Montenegro, Bulgaria, and Balkan Mountains.
12. Chinese white pine	*P. scipioniformis* Mast	Central China.
13. Japanese white pine	*P. pentaphylla* Mayr	Japan.
14. Korean pine	*P. koraiensis* Sieb. and Zucc	Japan, Chosen (Korea), Kamchatka, Manchuria, western China, and Formosa.
15. Creeping pine	*P. pumila* Rgl	Northeastern Siberia and Japan.
16. Small-flower pine	*P. parviflora* Sieb. and Zucc	Japan.
17. Armand's pine	*P. armandii* Franch	China.
18. Stone pine	*P. cembra* L	Alps, Karpathian and Ural Mountains, northern Russia, and Siberia.

In the alternate stage the fungus causing the white-pine blister rust attacks the leaves of currants and gooseberries. A few species are partially but not wholly immune to the fungus, so that we must at present consider all species susceptible and dangerous when in the vicinity of white pines *if either is affected with the disease.* There are about 50 different species of currants and gooseberries in the world; of these, 26 have been found infected by the fungus, but it is probable that all of them may be susceptible to the disease.

FIELD CHARACTERS OF THE DISEASE.

No 1-year-old or 2-year-old trees have been seen which showed the blister rust, and the senior writer believes that such trees never or very rarely have the disease. Diseased trees are often peculiarly stunted in appearance, the top having a compact, bunchy growth, not branching freely, as the white pine normally does. This is so characteristic that the diseased trees can often be picked out from among their healthy companions by it alone. The new growth of the last season is often shorter than in healthy trees. In badly diseased trees which have had the disease two or more years there may be orange-yellow spots upon the new wood and on the new needles. This is not commonly seen, however.

The stem of a healthy young white pine has practically a uniform diameter through each year's growth. Trees visibly affected with the blister rust usually have a more or less marked swelling where the first whorl of branches is given off from the main stem. This swelling usually tapers gradually for several inches, either upward or downward from the whorl of branches (fig. 1). In some few cases the stem (in 3-year-old trees) is swollen irregularly its entire length and has a very characteristic obese appearance. Scattered at intervals are often numerous wartlike bunches, located at leaf scars. Sometimes the swelling extends outward into the branches. These swellings may be distinguished from those caused by other organisms by splitting an affected stem, when it will be found that the wood retains a nearly uniform diameter even in badly swollen stems. The swelling is caused by an abnormal growth of the bark, so that the latter is often two or three times its normal thickness.

Rather rarely one finds cases where the bark has died in a ring around the stem without any swelling. These have been attributed to this disease also, as they have never been seen except in lots of trees which were known to be diseased and as similar effects are known to be caused by other species of blister rust.

Older trees (5 to 10 years) do not show the stunting and may not show the swelling markedly, but they have (at the affected place) an abnormally thick, scaly bark. Normally, the white pine does not form scaly bark on wood that is less than 10 to 15 years old.

The most certain symptoms of this disease are the fruiting bodies of the fungus. These show first as rounded yellowish white pustules pushing out through crevices in the bark. These pustules are rounded to elongate in outline, one-fourth to one-half inch by one-eighth to one-fourth inch. At first the bark breaks open and a rounded mass of an orange color pushes through the fissure. This attains a height of one-eighth to one-fourth inch and breaks open irregularly, allowing the powdery, orange-colored contents (spores) to escape. After the spores are given off, a delicate whitish membrane is left standing upright around the edges of the fissure and projecting somewhat from it. Still later this also disappears and one finds only an empty depression in the bark, with more or less rounded outlines and with some whitish masses of material in the rough bottom which upon microscopic examination prove to be masses of spores. These empty fissures are so characteristic that they may be easily recognized at once, even by the unaided eye. The yellow pustules, either before opening or after, are also very characteristic and are usually to be found between the last of April and the middle of June; the whitish membrane may be found at any time after June 1 up to late autumn; the empty fissures where the spores were earlier produced may be found at any time after June 1. Many times trees are found which have the swollen stem, but no spores or traces of pustules. These can usually be distinguished from trees affected by any other form of injury. An abrasion of the bark usually results in the formation of a swelling around the edges of the wound, but this can easily be distinguished from the swollen condition caused by the white-pine blister rust.

DISTRIBUTION OF THE WHITE-PINE BLISTER RUST.

An effort has been made to determine accurately the distribution of this fungus in Europe in the hope of finding some country or some region from which it is absent and consequently from which white pines may be safely imported. It has been reported from practically all Europe except the Balkan and Spanish peninsulas. It is prevalent in all the important countries of Europe exporting forest-nursery stock, and its prevalence in a district seems to increase with the extension of the forest-nursery interests. It is also reported from several localities in western Siberia, from Japan, from Sakhalin Island, and possibly from the Himalaya Mountains. In America there are known to be more than 230 localities where this disease has been found on imported trees.

SOURCE OF DISEASED WHITE-PINE STOCK FOUND IN AMERICA.

Every lot of white-pine stock diseased with the blister rust which was found in 1909 was traced directly to the nurseries of J. Heins's Sons, Halstenbek, Germany. This included a total of more than 220 separate lots which had been planted out by individuals. In the spring of 1909 this firm shipped to the United States approximately 2,500,000 white pines which were 2 and 3 years old, while since 1900 this firm has shipped to eastern North America over 4,500,000 of such trees. It is reasonable to believe that at least half as many more have been sent to other sections of this country. Our finding diseased trees, purchased from this firm, which have been in the country from one to six or seven years shows that their nurseries have been seriously infected all this time and that there is danger from every shipment of white pines which has been received from them. In 1910 only a few shipments are known to have been sent to this country by J. Heins's Sons and the same is true of 1911. In 1910 lots of white pines diseased with blister rust were received in this country from the three French firms of Levavasseur & Son, of Ussy; Barbier & Co., of Orleans; and E. T. Dickinson, of Chatenay. In 1911 a lot of white pines was received from J. Heins's Sons which bore mature fruiting bodies of the blister-rust fungus when they were unpacked. Some diseased trees were also received from an unknown French firm.

THE SITUATION IN AMERICA.

In 1909 it was discovered that the blister rust had been shipped into New York on 2-year-old white pines from Germany in the spring of 1908. Further investigation showed that it also was present on 3-year-old trees which had just been received from Germany and which had been sent from the same nursery to the States of New York, Vermont, New Hampshire, Massachusetts, Connecticut, Pennsylvania, and Minnesota. As soon as the presence of the disease was definitely determined, the New York authorities called a meeting of the representatives of forestry interests then known to be concerned or likely to be involved. At this meeting the State officials agreed to begin at once the removal of currants and gooseberries from the vinicity of the plantations of diseased trees in their States and to remove and burn all the trees which showed traces of the disease. Considering the difficult nature of the work it was done in a short time, but none too quickly, as was shown by the discovery of a single instance where the fungus had spread from the diseased imported pines to currants near by. The spores, however, were still inclosed beneath the epidermis of the currant leaves and had not yet been set free. So the disease was checked in the nick of time. Each spring the diseased white pines have been inspected and the diseased trees destroyed.

In 1910 white-pine trees affected with the blister rust were found by the State horticultural inspector in two different places in Ohio. In 1911 another lot of diseased trees was found in a third locality.

In Indiana a single diseased lot of white pines was reported as having been found in the State in 1910. This lot was promptly destroyed.

In Virginia the senior writer found the disease present in a shipment of white pines which had been sent to the State in 1911.

In New Jersey a single shipment of white pines which had been planted out the year before was found by the senior writer to have the blister rust. The owners promptly pulled them up and burned them.

In the spring of 1909 a very large lot of young white pines was received in Ontario, Canada, from the same nursery as those which were found diseased in this country.

The prompt action of the State officials in eradicating the disease as far as possible has, so far as now known, prevented the fungus from becoming established in this country. There are, however, undoubtedly other scattering lots of diseased trees which have been imported at various times. Information concerning these should be sent as promptly as possible to the proper State authorities or to the Bureau of Plant Industry, so that proper action may be taken before the disease becomes established.

METHODS OF COMBATING THE DISEASE.

American nurserymen have one effective method of combating this disease, i. e., to stop importing European stock of any of the five-leaved species of pine. A nurseryman who does this and who allows no Ribes to grow near his nurseries need have no fear of the blister rust. In places where the disease is already present, the only course is to remove the least valuable of the two hosts and destroy all diseased plants of the remaining host. Two or three inspections in July and August at intervals of 10 days to two weeks should make sure of all infected currants and gooseberries if the diseased and suspected ones are each time destroyed when found. In an infected lot of pines, inspections made during the month of May for several consecutive years should be sufficient, provided all suspicious trees are at once burned. In the case of an infected plantation or nursery of pines all wild and cultivated currants and gooseberries should be promptly removed to a distance of 300 to 500 feet from the edge of the area containing the pines. The pines should be very carefully inspected and all trees which show the least signs of this disease should be burned at once. Another inspection the following spring should result in the removal of those infected trees which were not detected the first time. Owing to the indefinite period of incubation of the fungus it is improbable that a single inspection will result in the removal of all the infected trees. All white-pine trees imported before they are 3 years old should be inspected when they reach that age, as the disease apparently does not become visible on younger trees. It is advisable that imported trees be held in nursery rows for at least one year, to determine beyond a doubt whether the disease is present or not. Any person buying young five-leaved pine trees should require the seller to guarantee the stock to be free from this disease, or, better, to have been raised from the seed in America, since any foreign stock is liable to be diseased. Those persons who insist upon importing white-pine stock will endanger their neighbors and the entire country in spite of the most rigid inspection that can be made. Foreign seed will not carry this fungus and is perfectly safe so far as the blister rust is concerned. The Office of Investigations in Forest Pathology of the Bureau of Plant Industry will teach inspectors the characters of the disease and so far as possible will make inspections where there are no State inspectors or where local inspectors are unable to do so. Specimens of white-pine trees or of Ribes leaves will be promptly examined and the results reported, with suitable recommendations for treatment. The Bureau of Plant Industry would also recommend that shipments of imported trees be reported to it, together with the name of the nursery or firm from which obtained. This will enable it to take prompt action in notifying owners of new developments in regard to treatment, etc.

PRACTICAL SUGGESTIONS REGARDING THE WHITE-PINE BLISTER RUST.

Danger to All American Five-Leaved Pines.

In the white-pine blister rust we have the very peculiar case of a foreign disease attacking an American tree in Europe and being brought on imported white pines to America with great danger to our native forests of this and other closely related species of trees. The disease has been known in Europe for about fifty years. It has not caused great damage to its original pine host, while its attacks on the American white pine continue with all their original severity and the disease is becoming more and more prevalent throughout Europe. Besides the eastern white pine of North America the disease has attacked two of the western American white pines. It has had many chances in Europe to attack pines which do not belong to the white-pine group, but has never yet been found upon any of them. It has shown a decided preference for the five-leaved or white pines and there seems to be danger of its attacking all of them. These pines occur naturally in the forests of this country except in the section extending from Texas and Oklahoma eastward and southward from the Ohio River. Even here the eastern white pine extends in the mountains as far south as northern Georgia and Alabama. Moreover, the Mexican and Himalayan white pines are commonly planted in this section as ornamentals and their use is increasing. Wild and cultivated currants and gooseberries are distributed throughout the country where any of the white pines naturally occur. It would be merely a question of time for the white-pine blister rust to spread over the country if it once became established.

The Disease Expected to Be Worse in America than in Europe.

A parasitic fungus newly introduced into a favorable climate or attacking new host species is likely to become more virulent and to cause greater and more complete destruction than before. Such a disease-producing fungus, when once established, is a permanent factor in the cultivation of its host plants. The histories of the potato blight, the grape mildew, the asparagus rust, the hollyhock rust, and many other parasitic fungi which have been carried from one continent to another prove the truth of these statements. In Europe the stone pine and the white pine are quite generally distributed, but none of the other known pine hosts of the blister rust are very generally distributed there. This practically limits the fungus to the above two species of pine in Europe. The stone pine is not usually seriously injured, while the American white pines are very seriously attacked. So far as known all the American white pines are liable to attack. With the great variety of climatic conditions existing in various parts of America it will be surprising if this fungus does not find some section suited to its best development. There is every reason to expect this disease to be as bad as or worse than it now is in Europe if it once becomes established here.

Estimates of Possible Damage.

A very crude idea of the loss which this disease might cause may be obtained from the following statements concerning the white-pine interests of America. The products of the white pines for the year 1908 were valued at $65,000,000. If only 1 per cent of loss was caused per annum (a very conservative estimate), the loss would be $650,000. The standing white pine has been estimated as worth $600,000,000, while the sugar-pine stand was valued at $120,000,000. These would give losses (at 1 per cent) of $6,000,000 and $1,200,000, respectively. The smaller alone far exceeds the valuation of all the white-pine stock that has ever been imported into the country. Should the disease become as aggravated as it is in England the losses would greatly exceed 1 per cent on all sizes of trees. The plantations of white pine now in existence in New England have been estimated to yield 200,000,000 feet of lumber between 1930 and 1950. In New England white pine is used in about 90 per cent of all the planting done. Fragmentary reports show that over 13,000 acres of land have been planted in the States of New Hampshire, Vermont, New York, Pennsylvania, New Jersey, Massachusetts, Connecticut, and Rhode Island with this one species. In the single year 1909 about 3,000 acres were planted in New York, Vermont, New Hampshire, Massachusetts, and Connecticut. This really important planting movement will be greatly checked, if not entirely eliminated, by this disease if it becomes established. The addition of this to its already heavy burden of difficulties will be fatal at the very moment the movement bids fair to accomplish results commensurate with our needs.

Actual Cost of Imported White-Pine Stock.

The original relatively low cost of European white-pine stock gives this an apparent advantage over American-grown stock. When to the original cost is added the higher expense of packages and the ocean freight, the apparent advantage in favor of European stock very largely disappears. While European stock as a rule compares favorably with American stock, there should be no advantage of the one over the other. It is possible to raise just as good stock here as in Europe. The risk of having the stock damaged by the long ocean voyage and the danger of importing destructive insect pests and fungous diseases which may soon cause far more damage than the entire value of the imported stock will deter any but the most venturesome from undertaking the importation of white-pine stock for the purpose of lessening expense. Moreover, American nurseries are now enlarging their output of such stock and one large nursery has reduced its prices until they compare very favorably with those in Europe.

Why Inspection for This Disease is Inefficient.

The blister rust vegetates in the bark tissues of pine for a number of months before any external signs of its presence are visible. This period of incubation is of uncertain length, but apparently varies from about one year to several years. During this time no inspection, however thorough, can detect the disease. A very good example of this is afforded by certain trees imported in 1908 when 2 years old, which the senior writer carefully examined at that time for this disease without finding the slightest signs of it. In 1909 they were visibly affected. The same thing has happened in others imported in 1909 when 2 years old. They now have the disease. Inspection can not detect affected trees except those which already have developed swellings or fruiting bodies. This is true of any single inspection which can be made. Repeated inspections are absolutely necessary in order to make sure that imported stock is free from disease. Such repeated inspections soon cost more than the value of the seedlings, to say nothing of the small saving between the cost of American and European stock.

Why No Nursery Can Be Given a Clean Bill of Health.

The giving of a clean bill of health to a nursery presents the same difficulties as inspection. An inspecting pathologist would need to know intimately the entire neighborhood surrounding the nursery; he would have to watch the nursery for at least two years, and in most cases longer, in order to be able to certify that this disease was not present. A single brief trip to Europe by an American pathologist could not possibly prove the absence of this disease in a single European nursery. On the other hand, it might prove its presence in some cases. The proposition would involve the residence in Europe of a pathologist who would spend most of his time in examining nurseries. Even this could not be conclusive unless the entire life history of the imported seedlings was known to him, or unless currants and gooseberries were found to be absent for a considerable distance around the nurseries.

Prevention Always Easier and Cheaper than Cure.

The essential feature of all plant-pathological work which has to do with combating disease is prevention rather than cure. This is necessarily so, since the nature of plants renders curative measures of very doubtful efficacy as a rule. If the disease can be prevented, the work is much more successful and satisfactory than when endeavors are made to stop a serious outbreak. This is preeminently the case with America and the white-pine blister rust. Comparatively small effort will keep it out, while no efforts likely to be exerted will stop it after it once becomes established here. The sooner the matter is taken in hand the cheaper it can be done. The situation in Europe is steadily growing worse so far as we are able to judge, and this would be the case in America should this disease obtain a secure foothold. The disease has been eradicated once in America and it can be done again and kept out of the country if the recommendations herein made are carried out.

The Work of Eradication Must Be Done by the States.

There are now no national laws in this country which apply to plant diseases. Hence the United States Department of Agriculture is without power to prohibit the importation of white-pine stock even if known to be diseased. This places all responsibility on the various State organizations. Some of the States have laws of some sort against serious plant diseases; those which have none should in self-defense pass them at once. The Office of Investigations in Forest Pathology of the Bureau of Plant Industry is ready to do all in its power, and to that end will instruct inspectors, make examination of material sent to it, and advise as to the best methods of combating the disease in specific instances. It has a limited supply of colored charts of this fungus which will be sent to applicants.

Caution to General Nurserymen.

Nurserymen who handle and grow any of the species of currants and gooseberries will do well to keep the white-pine blister rust in mind at all times. Its three appearances on Ribes in this country are utterly inexplicable and two of them may have been the result of importing new stock and varieties. Notwithstanding that it is supposed to attack only the leaves of Ribes, there is the possibility of its infecting buds or young wood and thus being carried on dormant bushes or cuttings. There is constant danger when Ribes or any five-leaved pine is imported from Europe, and the general nurseryman who imports either will but follow the dictates of simple prudence if he keeps currants and gooseberries well separated in his grounds from the five-leaved pines of any species and if he inspects these bushes once in a while every summer for the fungus. Specimens of diseased leaves should be sent to the State agricultural experiment station or to the Office of Investigations in Forest Pathology of the Bureau of Plant Industry for identification of the fungus infesting them.

National Power Needed.

Because of the seriousness of the white-pine blister rust in Europe and the great danger to American forests if the disease becomes established here, it is imperative that adequate measures be taken at once to prevent such misfortune. The destruction of all visibly diseased trees now in this country is not enough, although this is nearly all that has thus far been possible. Some of the States are inspecting imported white-pine stock and have thus prevented the scattering of the disease in a number of visibly infected shipments. The fact remains that there is more or less irresponsible importation of such stock. This must be stopped. The only available method seems to be national control of the importation of white pine by giving the Secretary of Agriculture power to prohibit such importations from certain nurseries or localities until they clean out the disease from their premises. Moreover, the importation of five-leaved pines should be subject to permits from the Secretary of Agriculture, so that every shipment may be traced if necessary. These measures would give absolute control of the disease, and they are the only ones which will do so. Canada has already prohibited the importation of the disease and requires proper notice of all importations of plant material.

THE WART DISEASE OF THE POTATO.

Potatoes rank as one of the most important farm products in this country. The Yearbook of the United States Department of Agriculture for 1910 estimated the production of that year at 328,787,000 bushels. Only five other farm crops are valued above this, namely, corn, cotton, hay, wheat, and oats.

Consequently, much alarm is felt over the probable introduction of the potato wart. This is a comparatively new disease, which was discovered on potatoes in Germany and Upper Hungary 16 years ago. Since that time it has spread with great rapidity and threatens to become one of the worst enemies of potato culture. It has not yet been brought into the United States so far as known, but has already crossed the Atlantic and become established in Newfoundland, where it was discovered by Dr. H. T. Güssow, Dominion Botanist. The close proximity of the disease to the United States makes it imperative that steps should be taken to guard against its importation.

DESCRIPTION OF THE WART DISEASE.

The wart disease is one which attacks the tubers principally, causing the formation of wrinkled, warty excrescences, which have given rise to the names "warty disease," "black scab," "canker," and "cauliflower disease." (Fig. 2.)

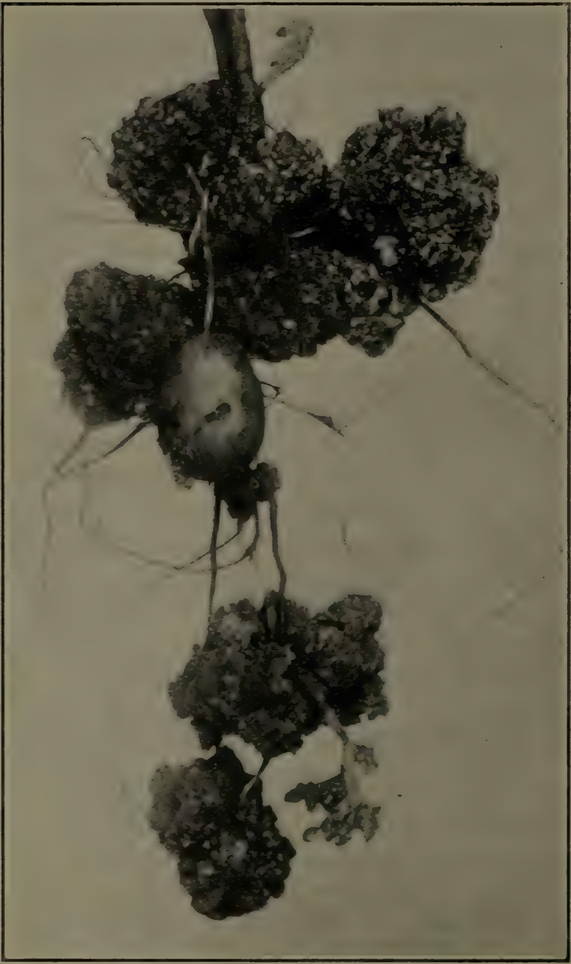


FIG. 2.—Potato wart. A plant of a diseased potato as it appears when dug, showing in the center a partially sound tuber covered with excrescences caused by the fungus at the base; also showing six malformed tubers adhering to the plant. (After Güssow.)

Since the tuber is the part of the plant chiefly affected, it is difficult to ascertain the presence of the disease until harvesting time. A bulletin issued by the Harper Adams Agricultural College, England, states that in the case of badly affected potatoes the tops remain green longer than those slightly or not at all affected. Infection may take place, however, in all the young tissues of the plant, the roots, underground stems, aerial stems, and even the leaves.

The organism *Chrysophlyctis endobiotica* Schilb., which is the cause of the disease, gains entrance into the tuber through the tender tissue at the eyes. In a mild attack the eyes first appear grayish, then turn brown, and finally black, while in a healthy tuber they are whitish or purplish in color. It is very difficult, if not impossible, to ascertain the presence of the disease in this stage. Such potatoes, when used as seed, prove to be the source of new infections wherever planted. It is due to this failure to recognize the disease in its early stages that potato wart has spread with such rapidity.

In more advanced stages the disease is very apparent. , One or more nodules, varying in size from that of a wrinkled pea to lumps as large or larger than the tuber itself, may be found. (Fig. 3.) These are green where they project from the ground and white below, turning as they grow old to dark brown or almost black. They have a wrinkled, coral-like appearance, much like the head of a cauliflower. "A still more advanced stage occurs when the fungus has utilized every particle of food stored in the tuber and has reduced it to a brownish black soft mass, giving off a very unpleasant, putrefactive odor." (See fig. 2.) Such potatoes can not be harvested whole. The black pulpy mass breaks up, liberating millions of sporangia (spore sacs) which live for years in the soil. These sporangia have been known to infect potato crops after an eight-year interval. So far as known, longer intervals have not been tested and it is possible that the fungus may live in the soil even longer than that.

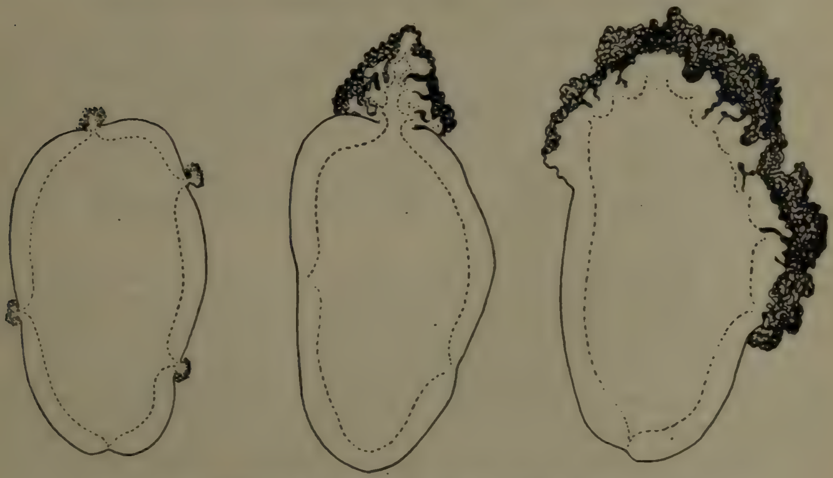


FIG. 3.—Potatoes cut in half, showing the wart disease. (After Güssow.)

LIFE HISTORY OF THE WART ORGANISM.

The organism causing the "wart disease" forms two kinds of sporangia—the summer sporangia and the winter, or resting, sporangia. The latter, which hibernate in the soil or on the tuber itself, germinate in the spring, freeing thousands of motile spores. These are capable of moving some little distance if moisture is present. If they come in contact with the eye of the potato they work their way into the delicate tissue in probably much the same way as does the organism which causes the clubroot of cabbage. The fungus then passes from one cell to another, stimulating the surrounding cells to rapid growth and division, which results in the warty protuberances on the tuber. Meanwhile, during the summer the fungus rounds up in some of the host cells and forms thinner walled summer sporangia, which soon germinate, liberating thousands of spores. These are capable of infecting other tubers during the same season. Late in the summer and in the fall before harvest time the thicker walled resting sporangia are formed and serve the purpose of carrying the fungus over the winter to infect the crop of next year. These sporangia may retain their vitality in the soil for eight years, thus making starving out a tedious process when a field once becomes infected. This means that potatoes must not be planted again in the soil where the disease has been present for at least eight years and possibly even longer.

MEANS OF DISTRIBUTION OF THE WART DISEASE.

The chief means of distribution of the wart disease is through the use of apparently healthy or only slightly diseased seed coming from infected fields. Such seed entering an uninfected territory is the origin of a new center for distribution. The Harper Adams Agricultural College in a recent bulletin states a case of one consignment of such seed causing the spread of the disease over a district with a 5-mile radius.

Too much emphasis can not be laid on the danger of planting seed taken from areas known to be infected. The danger would be lessened if tubers could be sorted into two lots—one diseased and one not diseased. It is practically impossible to do this, as slightly infected tubers can not be detected even by the most rigid inspection. For this reason various countries have enacted laws prohibiting the importation of any potatoes from infected areas. The United States also should have the power (which it does not have now) of rejecting potatoes from infected districts before the disease makes its entrance and becomes established here.

When the disease once enters a district it is frequently spread to adjoining areas through the use of infected manure. Consequently, diseased tubers should never be fed to stock unless boiled, as the sporangia pass unharmed through the animal. Prof. E. S. Salmon, of the South-Eastern Agricultural College, England, quotes one instance showing the danger of infection by manure. ''A certain dairy-farmer got one of his fields very slightly infected, but failing to recognize the disease he fed the small and diseased potatoes to cattle. The next year half his potato field was dunged with manure from his own yard, half with artificial manure. The potatoes manured with his own yard manure were all so badly diseased that he lost four-fifths of his crop; the other half of his field was practically free. As he was feeding his cattle last year in the same way and had turned them out on clover ley [field], he will also have infected a third field."[1]

Poultry and pigs which are allowed to roam over infected areas are another means by which the disease is carried from one field to another. Sporangia may also be carried on men's boots and tools which have not been thoroughly cleaned on coming from infected land.

CONTROL OF THE WART DISEASE.

Extensive experiments have been conducted in England with various fungicides and variety tests of potatoes. There seems to be a consensus of opinion that fungicides are not efficacious in controlling the disease. The following chemicals have been used on the soil with unsatisfactory results: Sulphur, soot, quicklime, ground lime, formalin, ferrous sulphate, calcium bisulphate, potassium bisulphite, calcium sulphite, sodium borate, potassium sulphid, copper sulphate, and lead acetate. Experiments were also conducted by sprinkling the sets before planting with sulphur, lime, lime and sulphur, soot, and soot and sulphur with equally unsatisfactory results.

Better results are claimed to have been obtained by testing different varieties of potatoes. A number of varieties have been found to be resistant in England, but one authority maintains that "all the best varieties of potatoes, i. e., all those most profitable to grow, are excluded as susceptible." He also states that one variety said to be immune is very susceptible to late-blight. None of these varieties are of commercial importance in the United States.

At present crop rotation is the best method of dealing with the disease. Unlike late-blight, which is checked some years by climatic conditions, the wart disease when once in the soil grows worse each year on land that is planted to potatoes. Since the fungus has been known to live in the soil for eight years, potatoes should not be planted in that soil during that period. Fortunately, so far as known the fungus attacks no other crop.

A vigorous effort should be made, if found in the United States, to eradicate the trouble. All infected tubers should be boiled or burned, and no more potatoes should be planted on that field for eight years. Stock should not be allowed to run over infected areas, and no part of any lot containing diseased potatoes should be used for seed purposes.

DISTRIBUTION OF THE WART DISEASE.

The wart disease was reported first in 1896 by Schilbersky from Upper Hungary. Since then it has been found in Westphalia, the Rhine provinces, and Silesia of Germany; in 1901 in England, where it has spread with great rapidity; and in Wales, Scotland, and Ireland. In 1909 Dr. Güssow reported it from Newfoundland. He also records its appearance in Scandinavia, France, and Italy.[1]

---

[1] The Journal of the South-Eastern Agricultural College, Wye, Kent, England, no. 18, 1909, p. 296.

DAMAGE IN ENGLAND.

The disease has been more widespread and destructive in England than in any other country. Under the destructive insects and pests acts, the Board of Agriculture and Fisheries made inspections of various districts in which the wart disease was present in gardens and published their findings in their annual report for 1909–10. The seriousness of the disease in some of the districts may be noted from the following quotations:

> *Brereton.*—J. L. has ¼ acre practically all spoilt.
>
> *Hammerwich.*—T. C.: Very bad.
>
> *Walsall Wood.*—H. C.: Disease on newly broken-up land.
>
> *Sutton Coldfield.*—W. C.: Disease much worse than last year in spite of dressing both seed and ground with sulphur. W. H.: Potatoes in allotment entirely destroyed.
>
> *Trentham.*—Thirty cases reported. J. T.: 75 per cent diseased. T. H.: Very bad; potatoes all one mass of disease. J. R.: Whole garden more or less affected except for one small patch on which no potatoes have been grown for 10 years. This is free.
>
> *Newstead.*—S. I.: Not a clean root in 600-yard garden.
>
> *Ecclestone.*—J. M.: Total yield, four-fifths of last year's yield.

From the above quotations it will be noted that in the worst cases from 75 per cent up to the entire crop was affected by the disease.

MEANS OF EXCLUSION.

At the present time the United States has no legislation that will prevent the importation of potatoes affected with wart. No quarantine is maintained against plant diseases, nor is the Secretary of Agriculture authorized to inspect or prevent the importation of potatoes known to be infected.

Recognizing the serious nature of the disease England made it a notifiable disease under the destructive insects and pest acts, 1877–1907. Under this act anyone failing to report the disease is liable to a fine of £10. The annual report of the Intelligence Division, Great Britain Board of Agriculture and Fisheries, for 1909–10, contains the following statement:

> The alarm caused by the rumors of the spread of the disease in England led several authorities abroad to impose regulations against potatoes from this country. It was at first proposed to prohibit importation altogether, but on a protest from the board being made the matter was reconsidered and new regulations were drafted which admitted potatoes accompanied by a certificate from the grower that the crop came from a farm on which no case of wart disease existed and by a further certificate from the board that no case of the disease had been reported from that neighborhood. These regulations were adopted by Malta, the Transvaal, the Orange River Colony, and, after a short period of total prohibition, by the Island of Guernsey. The other African colo-

---

[1] A Serious Potato Disease Occurring in Newfoundland. Bulletin 63, Central Experimental Farm, Ottawa, Canada, p. 4.

nies adopted precautions that did not entail the issue of a certificate, and the Island of Jersey prohibited the importation of potatoes from Great Britain altogether.

Australia has probably the most stringent quarantine measures against the wart disease with the exception of the Island of Jersey, which prohibits importations of potatoes from Great Britain. In March, 1911, the Governor General decreed that all potatoes imported must be accompanied by a certificate stating that such potatoes are free from the diseases of late-blight and potato wart and also that they were grown at least 20 miles from any place known to have been infected within five years. After the potatoes are landed they are planted in quarantine and if on maturity they show no signs of the disease, they may then be distributed.[1]

The Department of Agriculture of Canada has been empowered to take such action as may be necessary to prevent the introduction or spread of injurious insects and plant diseases. It has already done so with the wart disease of potatoes. Quoting from the Gardeners' Chronicle:[2]

> The Minister of Agriculture has power to prohibit the importation of plants from any given region should it be deemed necessary, owing to the presence of serious insect pests or diseases in such a region. This has been done in the case of potatoes from Newfoundland and the neighboring islands to prevent the introduction of potato canker (*Chrysophlyctis endobiotica*).

At present the most effective protection against the importation of potatoes is the tariff of 25 cents a bushel. Yet in spite of this the following quantities have come to our markets from abroad:

TABLE I.—*Importations of potatoes into the United States for 1907, 1908, and 1909, with their valuation.*

Country of origin.	1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Bushels.		*Bushels.*		*Bushels.*	
Austria-Hungary	741	$331	1,723	$746	1,331	$657
Belgium	75	84	6,889	3,650	260,932	109,699
Bermuda	87,048	135,569	80,711	109,561	139,590	176,315
Canada	11,393	5,970	177,102	80,006	1,181,693	549,029
Germany	39,419	19,934	62,059	38,368	79,024	44,373
Netherlands	5,704	2,184	38,892	18,169	74,697	26,352
Spain	7,730	7,408	11,246	11,596	9,144	7,333
United Kingdom:						
England	5,673	3,706	2,269	1,321	1,785,298	725,037
Scotland					2,684,588	1,099,858
Ireland					1,975,877	814,898
Other countries	19,134	17,399	23,061	19,615	191,792	123,483
Total	176,917	192.635	403,952	283,032	8,383,966	3,677,034

---

[1] In a later regulation issued July 29, 1911, subclause C of March 25, 1911, was withdrawn and potatoes, accompanied by an official certificate signed by a responsible officer stating that the potatoes were grown on premises known, after due investigation, not to be or to have been during the preceding 12 months infested with either wart disease or blight, might be permitted entry, and the growing of potatoes in quarantine for the first year was not required. On September 16 of the same year, Western Australia repealed the new conditions in so far as potatoes after being landed are to be grown for the first year in quarantine.

[2] Gardeners' Chronicle, vol. 50, 1911, p. 21.

Table I shows the large increase of potatoes exported in 1909 from Great Britain into the United States. This ranged from 5,673 bushels in 1907 to 6,445,763 bushels in 1909. It will also be noted that Great Britain, where the wart disease is most prevalent, exported in 1909 more than three times as many bushels into this country as all other countries combined.

The principal custom districts of potatoes in 1909 were as follows: Aroostook, Me., 152,406 bushels; Passamaquoddy, Me., 13,745 bushels; Bangor, Me., 291,288 bushels; Memphremagog, Vt., 24,802 bushels; Boston and Charlestown, Mass., 361,658 bushels; New York, N. Y., 5,232,514 bushels; Philadelphia, Pa., 1,299,480 bushels; Baltimore, Md., 379,510 bushels; Newport News, Va., 47,994 bushels; Buffalo, N. Y., 77,442 bushels; Niagara Falls, N. Y., 13,897 bushels; Huron, Mich., 194,845 bushels; Detroit, Mich., 177,788 bushels; Arizona, 43,993 bushels; and Porto Rico, 23,397 bushels. Smaller importations were received in the following States: New Jersey, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Ohio, Wisconsin, Illinois, Minnesota, North Dakota, South Dakota, Missouri, Montana, Idaho, Washington, Oregon, California; and in the Territories of Alaska and Hawaii, 49,267 bushels. Total, 8,383,966 bushels.[1]

Since this country has no legislation which can in any way prohibit the importation of infected potatoes, seed which Canada and other foreign countries will not accept can be shipped at will into the United States. On account of our nearness and lack of quarantine regulations there is no question but that Newfoundland will ship her potatoes here which are now refused in Canada. Some legislation in regard to the wart disease should be enacted whereby the Secretary of Agriculture would have absolute control of all importations of potatoes.

PRESENT METHOD OF INSPECTION FOR INSECTS ENTIRELY INADEQUATE WHEN APPLIED TO FUNGOUS PLANT DISEASES.

The present system of inspecting imported nursery stock for noxious insects may be briefly outlined as follows: Customhouse officers send to the Entomologist of the United States Department of Agriculture a daily report of importations of nursery stock covering the following items, among others: (1) Consignor, (2) consignee, (3) kind of stock, (4) number of packages, etc. Each of these statements may be either indefinite or erroneous. Under "consignor" may be given the name of a European agent, whereas the information really wanted is the name of the nursery from which the stock originated. Under "consignee" is very often found merely the name of an agent or broker, with no information as to the true destination of the stock. The "kind of stock" may be so indefinitely worded that practically no information is given; it should give the specific name of each kind of stock. The statement as to the number of packages may be exceedingly indefinite as to the actual quantity of trees. The exact number should be given in round numbers at least.

---

[1] Information furnished by the Bureau of Statistics, United States Department of Agriculture.

Even with these statements in hand it is impossible in many cases to tell what shipments contain a certain suspected kind of plant, from what nursery or person they came, or to whom and where they are ultimately going, all of which information is necessary in order to decide whether inspection is needed and to notify the proper inspection authorities so that they may make the inspection if necessary. Besides the notice from the customhouse, the railroads send in notices of lots forwarded by them. Upon receipt of these statements the entomologist informs the inspectors of each State about the stock needing inspection which is on its way to that State. This procedure works fairly well for insect pests but is far from perfect in the actual results obtained. See Farmers' Bulletin 453, entitled "Danger of General Spread of the Gipsy and Brown-Tail Moths through Imported Nursery Stock," by C. L. Marlatt, for statements regarding this.

For the detection of dangerous fungous plant diseases this method is exceedingly defective and inefficient and causes the useless expenditure of much money and time in tracing uncertain importations. The past two springs the Office of Investigations in Forest Pathology has sent notices to the State inspectors concerning all imported lots of white pines, but it is very doubtful whether all, or even the greater part, of the importations were known. A very radical change is needed to make the inspection service for plant diseases as efficient as it should be. A permit system appears to be the only adequate method of obtaining the information which is absolutely necessary in order to cope intelligently with the situation.

At present pathologists of the United States Department of Agriculture have absolutely no power with regard to diseased stock in any State or Territory; hence, State officials must handle the inspection and take such measures as their laws indicate. The States vary much in the efficiency and execution of their inspection laws, the protection afforded ranging from practically none to fairly good. Even in the best protected States it is not uncommon to find imported nursery stock which has reached the State without the knowledge of the inspector. In the other States it is very common for such lots to gain entry entirely unknown to the proper authorities. Besides all this, the State laws apply only to plants raised within or shipped from outside to some point within the State and then unpacked and planted out; that is to say, any amount of stock may be imported and shipped again to other States without being required to pass any inspection. In nearly all States the imported stock may even be repacked into smaller lots before being reshipped. The next State receiving such stock receives it under the assumption that it was raised in the former State, and it is inspected or not as the laws of the latter and the efficiency of its inspection service may determine.

It is quite a general custom among nurserymen handling ornamental stock to import their supply of 1-year-old evergreens. The cost is small and this procedure saves annoyance and the bother of handling seed beds of their own. It is also not uncommon for these nurserymen to buy older stock and fill their orders with it. The ornamental trade usually calls for small lots of each species used, thus giving a maximum distribution to diseased trees. In this way a lot of 50,000 trees might very easily be sent to hundreds of different places throughout the country. Furthermore, in such cases it is impossible to trace all such trees to their final destination, and it is exceedingly difficult to learn of the importations so that they can be inspected before being distributed to the planters.

Besides the nurserymen handling ornamental stock, there is an increasingly large number of private persons who import directly for their own use, in lots of five thousand to several hundred thousand. These are especially hard to find.

A third class of importers is the brokers who handle only large lots; these import simply, and sell their stock to nurserymen or to private individuals in lots ranging from one thousand to hundreds of thousands. The broker's transactions in many cases do not come under the State laws and much of their stock is never inspected. For instance, a lot of trees is received by a New York broker at the Hoboken wharves; he immediately sends some of it to a Middle Atlantic State. That stock is not inspected by the New Jersey inspectors, as its destination is another State and it is not unpacked in New Jersey. When received at its destination, the shipment is either planted out in the nursery or is again split up and forwarded to still other localities, partly in other States, where it finally is planted out. In each shipment of the lot from one State to another no inspection is made by the State from which the shipment is made, and if the laws or inspection are defective for any reason in the State receiving the shipment the diseased trees may run the entire gamut without ever passing under an inspector's eye. Many such cases occur each spring.

There are very few of the State inspection laws which cover anything but nursery stock and orchards. A few have passed laws which apply to plants and parts of plants of all kinds. At present there is no inspection of potatoes, and hence the wart disease will surely enter the country, if it has not already done so. It will inevtably take several years for all the States to pass inspection laws for potatoes, and meantime the wart disease will surely become established. Even then the disease often is in such a state that inspectors can not detect it. Hence, it is of the greatest importance that adequate national power be given to regulate importations of white pines and potatoes.

The laws of most States apply only to insects and in some cases to a few specific fungous diseases. Only very few have a law which permits action against new diseases, such as the white-pine blister rust or the potato wart disease. Moreover, the State inspectors are educated entirely for the detection of insects, while very few have the training and experience necessary for the detection of fungous diseases. All the States should extend the possible powers of their horticultural inspectors, especially so that quick action may be taken with dangerous new diseases. Moreover, the various States should as soon as possible get competent plant pathologists especially for inspection work, who shall cooperate with the present horticultural and entomological inspectors. These men should be given legal authority and sufficient appropriations so that they can do thorough work.

SUMMARY.

The white-pine blister rust and the potato wart, two plant diseases which have caused great damage in Europe, are being brought into America regardless of the danger of their becoming permanently established in this country. They can not be efficiently handled by inspection. If they once become established here they are practically sure to have a disastrous effect, the former upon the growth of white pine and of other closely related pines which are among our most valuable timber trees and the latter upon the cultivation of one of our greatest food crops, the potato.

The only practical method of dealing with these two diseases is that of total prohibition of the importation of white pines and potatoes from certain localities. This can be secured by giving the Secretary of Agriculture quarantine power in connection with dangerous fungous diseases similar to that he now has for animal diseases. This power should be accompanied by a permit system for all plant importations, as only in this way can information concerning all importations be obtained. These ends can not be secured in any other way. Moreover, these measures must be made effective at once or the only opportunity for preventing these two diseases from becoming permanently established here will be lost.

○

Issued April 13, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 490.

BACTERIA IN MILK.

BY

L. A. ROGERS,
Bacteriologist, Dairy Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

Apr. 2d, 1917

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., February 3, 1912.

Sir: I have the honor to transmit for publication the manuscript of a revision of Farmers' Bulletin 348, "Bacteria in Milk," by Mr. L. A. Rogers, of the Dairy Division of this bureau. This paper in its original form appeared in the Yearbook of the Department for 1907 and was later issued as a Farmers' Bulletin. This revised edition is designed to supersede the old bulletin and it therefore should be published under a new number.

Respectfully,
A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

CONTENTS.

Page.
Milk—its composition and characteristics . . . 5
Bacteria—their nature . . . 5
Relation of temperature to growth of bacteria . . . 8
Sources of bacteria in milk . . . 9
Flavors in milk . . . 11
Souring of milk . . . 12
Sweet curdling and digestion . . . 14
Bitter milk . . . 15
Ropy or stringy milk . . . 16
Miscellaneous fermentations . . . 17
Disease-producing bacteria in milk . . . 18
The handling and care of milk . . . 20

ILLUSTRATIONS.

Page.
Fig. 1. Bacteria of the spherical or coccus type . . . 6
2. Bacteria of the coccus type hanging together in chains . . . 6
3. Typical rod-shaped bacteria (bacillus type) . . . 6
4. Bacteria with hairlike appendages . . . 6
5. Typical lactic-acid bacteria . . . 12

BACTERIA IN MILK.

MILK—ITS COMPOSITION AND CHARACTERISTICS.

A study of the changes produced in milk by bacteria is a study of the decomposition of the constituents of milk. Many of these changes are so complex that they can not be discussed in a paper of this nature. The fats are usually little affected by the growth of bacteria in milk. The sugar, on the other hand, is frequently fermented, and various acids, gases, and alcohol may result. The caseīn and the albumin are decomposed by many bacteria. The products of the decomposition sometimes have sharp or disagreeable flavors and not infrequently unpleasant odors.

It has been shown that milk contains certain digestive principles—the so-called unorganized ferments, or more properly enzyms—which slowly digest the milk. Fresh milk, collected and held without bacterial contamination, will spoil in time unless these enzyms are destroyed by heating.

BACTERIA—THEIR NATURE.

To understand the changes that take place in milk it is necessary to consider briefly the nature of the minute organisms causing these changes.

The basis of all life is the mysterious jellylike substance to which scientists have give the name of protoplasm. In its various forms it constitutes the actual living, changing part of every living thing, plant or animal. The simplest living things are merely shapeless, naked masses of this protoplasmic jelly. Bacteria show the first differentiation toward the complete plants with which we are familiar. The protoplasm is covered and held in definite shape by a very thin and delicate wall. They are then tiny one-celled plants. The plants growing in our gardens are made up of an infinite number of cells, organized like the workers in a community, each kind doing a particular work and all necessary to the complete plant. In bacteria, however, each cell is a complete plant in itself. (See figs. 1–4.) Their food must be in a condition to pass through the cell wall to the living protoplasm within. It must be in solution in water and it must be diffusible—that is, it must be a substance that will pass through a membrane, otherwise it could not pass through the cell wall of the plant. Not all substances soluble in water will pass through a membrane. Thus albumin, while soluble, can not, as will be pointed out later, be used by bacteria until it has been changed.

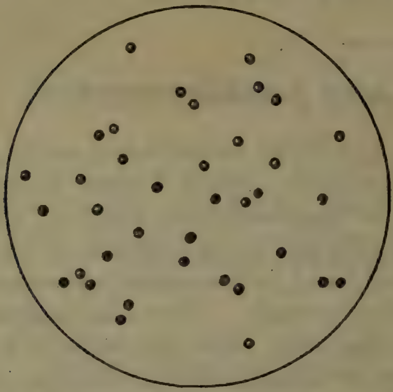


FIG 1.—Bacteria of the spherical or coccus type.

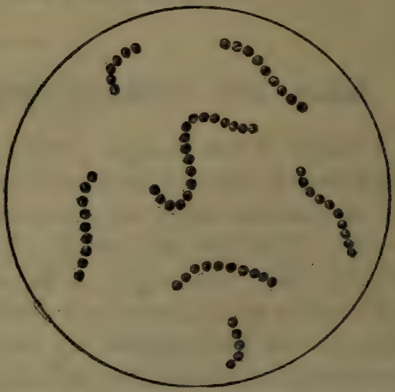


FIG. 2.—Bacteria of the coccus type hanging together in chains.

On the other hand, sugar is both soluble and diffusible and probably can be used for food by bacteria without previous change.

Through infinite generations of dependent existence bacteria have lost their ability to live independently and have become parasites or saprophytes. In other words, they are no longer able to elaborate their nourishment from the simpler compounds existing in the air and the earth, but must depend on higher, better organized plants or animals to prepare their food for them. Hence we find them living only where there are present at least traces of animal or plant tissue. If they depend on living tissue, they are called parasites; if they

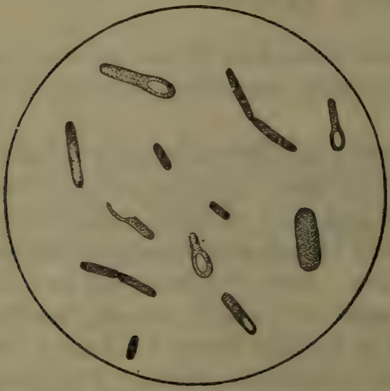


FIG. 3.—Typical rod-shaped bacteria (bacillus type). In some of these spores are shown as clear areas.

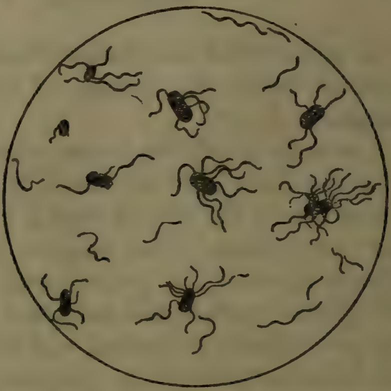


FIG. 4.—Bacteria with hairlike appendages which enable them to swim about in water or milk.

obtain their nourishment from dead, partly decomposed plant or animal matter, they are known as saprophytes.

The growing corn plant is so delicate that it is killed by a short exposure to a freezing temperature or to a scorching sun; yet the dried corn kernel will stand the most intense cold, long drying, or comparatively high heat, and when proper conditions are provided will grow. In a somewhat similar way some bacteria are provided with means of withstanding unfavorable conditions. These bacteria form a small round or oval body in the interior of the cell. When the bacterium dies, this spore, as it is called, is set free. Like the seeds of the higher plants, it is able to survive long drying and great extremes of temperature. To destroy spores by heat, it is necessary to expose them to long-continued boiling or for a short time to temperatures above the boiling point of water.

The bacteria are so small that it is difficult to form a conception of their dimensions. It is only when we consider them in the aggregate that they reach units of measure with which we are familiar. It is estimated that if 25,000 averaged-sized rod-shaped bacteria were placed end to end their combined length would equal 1 inch. The weight of an average bacillus is so small that it has been estimated to would take over 600,000,000,000 of them to equal 1 gram or 16,800,000,000,000 to weigh 1 ounce.

What the bacteria lack in size is made up in their great numbers and powers of reproduction. A cubic centimeter of milk, which contains about 25 drops, frequently contains thousands, sometimes millions, even hundreds of millions, of bacteria. A single drop of sour milk may contain 40,000,000 bacteria.

Bacteria reproduce themselves by a very simple process, known as fission. The cell becomes elongated and a partition wall is formed across the middle. The two cells thus formed separate, and we have two bacteria. Higher plants may take weeks and months, or even many years, to grow to maturity. These simple plants known as bacteria, however, under favorable conditions may complete their growth and reproduce themselves in less than an hour.

Bacteria, in common with all other living things, obey certain fixed laws. Certain elements and certain combinations of elements are necessary for their growth. There seem sometimes to be exceptions to these laws, but closer study shows that these exceptions are only apparent.

It would be very easy for the layman to obtain the impression by reading popular descriptions that bacteria are peculiar and unusual plants, having little in common with other forms of plant life. On the contrary, bacteria, in their form, habits of growth, and life processes, closely resemble many other simple plants, like the algæ, the yeasts, and the molds.

RELATION OF TEMPERATURE TO GROWTH OF BACTERIA.

The relation of bacteria to temperature is most interesting and important. A certain amount of heat is essential and a certain amount is fatal. Each particular variety of bacteria has an upper and a lower temperature limit beyond which it does not grow and a certain temperature, called the optimum, at which it grows best.

Most forms occurring in milk find their optimum temperature between 80° and 100° F. At a few degrees above 100 many forms will not grow at all and if the temperature is increased a point is soon reached at which only exceptional kinds will grow. At 125° the weaker cells of the ordinary forms soon die, but there are some varieties which occur in milk that grow readily at this temperature. An exposure of 10 minutes at 150° to 160° F. is fatal to a large part of the bacteria that do not form spores. However, the point at which they are destroyed by heat varies greatly, and many vegetative bacteria survive 150° F.

Spores, as previously mentioned, are destroyed only by prolonged boiling, exposure to steam under pressure, or to a high degree of dry heat. With dry heat, such as is obtained in an oven, much higher temperature and longer exposures are necessary to secure the same results. In the laboratory small flasks of milk are sterilized by holding them in a small steam boiler at a temperature of 248° F. for 15 minutes.

If the milk is cooled and held at 50° F. or, better still, 40°, growth is checked at once and multiplication is very slow. One writer has represented the relative increase of bacteria in milk held at different temperatures as follows:

Multiplicaton of bacteria in milk held at different temperatures.

Milk held at—	Relative number of bacteria at the end of—				
	0 hour.	6 hours.	12 hours.	24 hours.	48 hours.
68° F.	1	1.7	24.2	6,128.0	357,499.0
50° F.	1	1.2	1.5	4.1	6.2

In the foregoing table, 1 is assumed to represent the number of bacteria in the fresh milk, and the relative numbers which will be found at the end of 6, 12, 24, and 48 hours, at the two temperatures, are shown in the succeeding columns. These figures are based on a number of actual counts and illustrate the effect of a difference of 18° on the multiplication of bacteria. If the milk had contained at the beginning 1,000 bacteria, the part held at the lower temperature would have contained at the end of 24 hours only 4,100 bacteria, while the other would have contained at the same stage 6,128,000. If the temperature is lowered below 40°, the growth is very much retarded and at the freezing point it ceases entirely for a short time at least. If milk is held at 32°, or even a few degrees lower, it does not form a solid piece of ice, but the water slowly forms into crystals and the milk remains in a semifluid condition. After a few days some of the bacteria begin to grow again and after a time may attain enormous numbers. These bacteria are not the ordinary kind, and they may cause marked changes in the chemical character of the milk without appreciably changing its appearance. It is therefore unsafe to assume that milk held for several days at a low temperature is safe because it looks all right.

The temperature may have a decided influence on the kind of bacteria growing in milk as well as on the numbers. There is a constant struggle for existence among the various kinds of bacteria in the milk, and those which find the conditions most favorable or succeed in so changing the milk that it is more favorable or less unfavorable to them than to other kinds will gradually crowd the others out. If a sample of milk is divided into three parts and held at three different temperatures—as, for instance, 35°, 70°, and 98°—the bacteria predominating in each of these parts at the end of two or three days will probably be quite different. Thus we see how it is that milk may undergo so many changes. Even when milk is handled in the same way day after day there may be marked differences in its appearance or flavor. Changes in the conditions so slight that they may escape our notice may produce great variation in the final results. The amount and nature of the contamination must necessarily vary more or less from day to day. Even with the same contamination the temperature of the atmosphere may change the whole course of the fermentation.

SOURCES OF BACTERIA IN MILK.

It has been assumed by many writers that milk is formed in the udder entirely free from bacteria. This has frequently been disputed and is still a matter of some doubt. However, the best authorities agree that milk is bacteria-free when formed, unless the udder is so injured or diseased that there is a direct passageway from the blood vessels to the milk ducts. It should be remembered that an injury so slight that it would escape the most careful examination might be sufficient to allow the passage of bacteria.

Even if the milk is secreted bacteria-free, it is very difficult to obtain it perfectly sterile. Bacteria work their way into the milk cistern through the opening in the teat and find there conditions under which they can grow and multiply. This growth is ordinarily confined to the lower part of the udder, and the greater number of the bacteria are washed out with the first few streams of milk. Sometimes, however, the growth may extend into the smaller milk ducts, and the last part of the milk will contain nearly as many bacteria as the first.

Inflammation of the udder or fermentation of the milk in the udder rarely occurs, because there is only a very small amount of milk held in the udder, and most of the bacteria found there have little or no effect on milk. It is also true that fresh milk, like the blood, contains some substance which has an inhibiting influence on bacteria. This influence is so slight that it is probably of little practical importance, but it may have some relation to the comparatively slow development of bacteria in the udder.

The real contamination occurs after the milk has left the udder. In spite of careful milking, dirt, particles of dust, hairs, even bits of manure from the flanks or udder of the cow, may fall into the milk. All of these things invariably carry more or less bacterial contamination. Manure usually contains large numbers of bacteria, many of them being kinds which produce very undesirable changes in milk; and the dry dust of the stable floor contains great numbers and varieties of bacteria. This dust soon settles, and an open milk pail catches a surprisingly large amount.

But the contamination does not end here. The pails or the cans may not be properly cleaned, and the corners or seams may hold small particles of dirt or sour milk. These impurities are full of bacteria, which quickly find their way into the milk. The cloth through which the milk is strained may not have been properly scalded, and the bacteria are not only not all destroyed, but have actually multiplied in the damp cloth. When the strainer is used again many of these bacteria are washed out by the milk.

If a cooler is used it may add to the contamination if it is placed so that it catches dust. Finally, the bottles in which the milk is distributed may not have been properly washed and steamed, and thus may become another source of contamination.

The contamination from each individual source may be small, but taken all together it has a serious influence on the quality of the milk. If extraordinary precautions are taken to prevent contamination, the number of bacteria in the fresh milk may be kept down to a few hundred per cubic centimeter; with careful milking it may easily be kept within a few thousand; with careless milking and handling the number will vary greatly with circumstances and may exceed 100,000.

The bacteria in milk from cows kept in stables may be different from the bacteria in milk from cows on pasture. Bacteria which occur rarely in milk during the winter months may become numerous in the summer, and specific fermentations which are almost unknown in the summer may appear in the autumn or winter.

It should not be assumed that all bacteria are harmful either to milk or to the human system. In fact, many kinds of bacteria will grow in milk for a long time without changing its taste or appearance, while many of the fermentations which make milk undesirable for direct consumption are used in making butter and various kinds of cheese. Very few of the bacteria cause disease or produce poisonous by-products.

FLAVORS IN MILK.

Milk may acquire abnormal flavors and odors in various ways:

(1) The cow may, through some pathological condition, produce milk with an unusual flavor. This may occur when the cow shows no outward sign of disorder and usually lasts for a short time only.

(2) Highly flavored foods may impart their peculiar flavors to the milk. The disagreeable results of feeding even small quantities of wild onion, turnips, and similar feeds are unfortunately too familiar to need comment. Other feeds with a less pungent taste no doubt affect the flavor of the milk to a less degree.

(3) Milk, especially warm milk, takes up the odors and flavors of the surrounding air with great rapidity. The flavor thus acquired may be so slight that it ordinarily passes unnoticed, or it may be so pronounced that anyone may recognize its source.

(4) The flavor of milk may be materially changed by the growth of bacteria, with the infinite variety of by-products which result from their development. If milk is sterilized and then inoculated with some one kind of bacteria, a certain flavor, frequently very pronounced, will result; and under the same conditions this particular variety will always produce the same flavor. Another kind may produce an equally pronounced but entirely different flavor, while some species may grow for a long time without causing any noticeable change. In ordinary milk, however, the conditions are different, in that many kinds of bacteria are growing together and the milk is usually consumed before there is any marked change in the flavor.

When a number of different kinds of bacteria grow together, as they usually do in milk, the development is not equal. One variety finds the conditions of food or temperature or acidity more suited to its peculiar habits of life and develops more rapidly than other kinds. In a short time this rapidly growing form may so change the milk that, while the conditions are more favorable to its own growth, they become less and less adapted to the needs of the others. In the course of time this form crowds out all others, and an examination would show large numbers of this kind, while the others originally present would have entirely disappeared or would occur only occasionally. It is in this way that the special fermentations develop.

If milk shows a peculiar flavor when it is first drawn it is safe to say that the flavor is not produced by bacteria, but by the cow, usually through something in the feed. If, on the other hand, the fresh milk is normal and the flavor develops as the milk stands, it is usually due to bacteria.

SOURING OF MILK.

Many of the lower plants find sugar a suitable food. In making use of this food, the sugar is chemically changed and in its place we find many new chemical compounds differing widely from the sugar from which they originated. Some bacteria in this process form various kinds of acids and gases. Among these is a large group of closely related bacteria which cause the souring of milk by breaking up the milk sugar into lactic acid. On account of this peculiarity they are commonly called the lactic-acid bacteria (fig. 5). Typical lactic-acid bacteria do not form gas. They do not have spores and therefore are destroyed at a comparatively low temperature. They are extremely widely distributed, and it is only under exceptional conditions that milk is obtained entirely free from them. They seldom or never occur in the udder itself, but probably are introduced into the milk with the hair, bits of feces, and dust that fall into the milk in the barn.

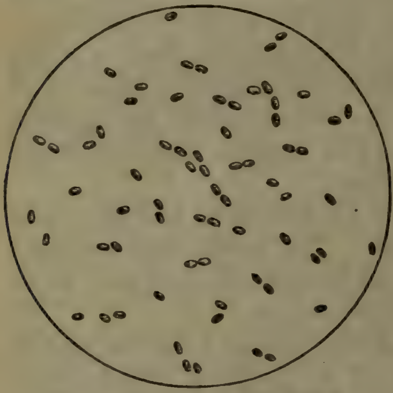


FIG. 5.—Typical lactic-acid bacteria.

Milk is an excellent medium for the growth of lactic-acid bacteria, and under favorable temperature conditions they multiply with astonishing rapidity.

The acidity of the milk is so closely connected with the life processes of this group of bacteria that it may be taken as a rough measure of their development. The acid, as fast as it is formed, unites chemically with the casein, which exists as very fine particles suspended in the milk serum. When the acid reaches a certain per cent, the acid casein is precipitated, and the milk is said to have "curdled" or "clabbered." This result may be hastened by heating. If milk or cream that is slightly sour is added to hot coffee, or is otherwise heated, it curdles.

Milk which has undergone a strictly lactic-acid fermentation has a firm curd, free from gas bubbles, and with a small amount of whey on the surface. When shaken the curd breaks up into small particles which settle slowly, leaving a clear whey. The milk should have a pleasant acid taste. So far as is known, none of the products of the bacteria of this group is of a poisonous nature.

Some of the bacteria sometimes classed with the lactic-acid bacteria form acids other than lactic, together with large quantities of gas. Milk curdled by bacteria of this class shows gas bubbles and has a disagreeable taste.

Not only are the lactic-acid bacteria able to grow in an acid medium, but to a certain point the acid is a favorable influence. Many bacteria, however, find the acid detrimental to their development and are not able to grow long in milk in competition with lactic-acid bacteria. When the milk begins to taste sour, the growth of nearly all nonacid-forming bacteria is checked. The activity of the actic-acid bacteria themselves is checked and finally ceases entirely when the acid reaches a certain concentration, which varies with different varieties. Consequently sour milk usually contains a nearly pure culture of one or at most two or three closely related varieties of bacteria.

If a stoppered full bottle of ordinary raw milk is allowed to stand n a warm room for several days it usually develops a very sharp acid taste and frequently a somewhat slimy condition. This is due to the growth of a group of bacteria which occurs normally in milk but in small numbers only and which develop when certain favorable conditions are provided. They sometimes produce two or three times as much acid as the ordinary lactic-acid bacteria. In Turkey and neighboring countries milk fermented with these bacteria is a common article of food. In recent years the public has become familiar with these bacteria under the name of *Bacillus bulgaricus* or the Metchnikoff bacillus.

While the lactic-acid bacteria are considered very beneficial in butter and cheese making, they are undesirable bacteria from the standpoint of the milk dealer or consumer. It is almost out of the question absolutely to prevent their presence in milk, but the initial number may be much reduced by observing a few simple rules of cleanliness in handling the milk. Every precaution which reduces the amount of dirt in milk reduces the number of bacteria correspondingly. The important factors here are freedom from dust at time of milking, brushing the cows, wiping the udders, and small-mouthed milk pails. It is also of great importance to cool the milk as soon as possible after milking to below the temperature at which lactic-acid bacteria grow rapidly. This temperature is controlled by practical conditions, such as the temperature of the water available for cooling, but it should not be higher than 50° F.

SWEET CURDLING AND DIGESTION.

It sometimes happens that milk curdles without showing the usual acid taste. This is followed by the separation of a straw-colored whey, which slowly increases until the curd has nearly all disappeared. This condition is the result of a series of complicated changes brought about by bacteria.

When milk is taken into the stomach, especially the stomachs of young animals whose diet is largely or wholly milk, a certain constituent of the digestive juice precipitates the casein, forming a firm curd. This curd resembles the acid curd in appearance, but differs from it chemically and has no sour taste. The part of the digestive juice which produces this change is the rennet, with which we are familiar in cheese making and in the junket tablets of the kitchen. It is what is technically known as an enzym, and while it has some of the properties which we ordinarily attribute to living beings, its action is purely chemical.

In this precipitated condition the casein is not in a form to be used by the animal. It must be so changed that it will go into a solution and pass through the membranes lining the digestive tract. This change is brought about by another enzym, pepsin. Pepsin changes the curd rapidly and completely into compounds soluble in water.

A process similar to these digestive processes in the stomach takes place in milk when it is subjected to the action of certain kinds of bacteria. The bacteria have no stomachs, but some of them have the ability to secrete enzymes somewhat like the rennet and the pepsin of animals. Thus the milk can or bottle becomes in a certain sense the communistic stomach of myriads of bacteria. From each cell is given out a trace of rennet and the digesting enzym. These enzyms have the peculiar property of acting continuously without reduction of their power. Thus it happens that the milk is curdled in a few hours and the casein is slowly converted into products capable of passing through the delicate membrane surrounding the bacteria. The food thus produced is obviously far in excess of the needs of the bacteria.

A large group of bacteria, more or less closely related, produce changes of this nature. Some of them form by-products with disagreeable odors and tastes and some form gases. They are found normally in the soil, in water, in the filth of the stable, or the dust that floats in the air. They are invariably found in milk in greater or less numbers. They are ordinarily checked by the activities of the lactic-acid bacteria and become predominant only under special conditions. When, through careless handling, any exceptional number of bacteria of this class are introduced into the milk, they may bring about rennet curdling and digestion before they are suppressed by the acid produced by the lactic-acid bacteria.

Again, in hot weather the temperature of the milk may be so high that it is more favorable to the digesting bacteria than to the lactic-acid bacteria and the former gain the ascendency.

BITTER MILK.

The distinct bitter taste which sometimes appears in milk may be caused by (1) certain weeds that the cow has eaten, (2) an abnormal condition of the udder, (3) an advanced period of lactation, or (4) the action of certain bacteria. The first three causes of bitter milk need not be discussed in this paper. It is probable that the bacteria causing bitterness are not at all uncommon and that they could be found in many lots of milk showing no bitterness. Some of these bacteria form acid and sour the milk; the more common forms, however, form little acid, and are checked by the growth of the lactic-acid bacteria. Many of these form spores and thus survive heating which destroys a large part of the vegetative bacteria and thus changes the normal bacterial balance. For this reason bitterness has been most frequently observed in milk pasteurized at too high a temperature, imperfectly sterilized milk, or milk collected under conditions that exclude the greater part of the lactic-acid bacteria.

The bacteria causing bitterness in unheated milk are more frequently those of the acid-forming classes, which are better able to compete with the lactic-acid bacteria. The acid formed by this group is usually butyric and not lactic. Some writers have stated that the bitterness is caused directly by the butyric acid. Nearly all of the bateria known to produce bitterness bring about an active digestion of the casein and albumen, and it is probable that the bitter principle is formed in this decomposition. In most cases, however, the bitterness becomes evident before there is any visible sign of change in the milk.

Bitter milk may occur as an epidemic, persisting day after day and causing great trouble. This may be due to some constant localized source of infection which adds each day unusual numbers of bacteria to the milk. In some cases it has been found that the udder of a cow was infected. This should be determined by carefully cleaning the udders of all the cows and milking from each quarter of the udder of each cow into fruit jars or bottles which have been previously cleaned with boiling water.

In case one of these samples shows a well-developed bitterness while others remain normal, it may be assumed that the source of infection is the udder of the cow giving this milk. In that case there should be injected into the udder after each milking a solution of 1 part hyposulphite of soda in 100 parts of water.

It is probable in many cases that the source of infection is not localized. If through some combination of circumstances the lactic-acid bacteria are suppressed, other kinds become predominant. The utensils, the milk room, and the stable gradually become inoculated with these bacteria or their spores and each new lot of milk is thoroughly inoculated. The bitter-milk bacteria may be one of the new forms. In this event it may be necessary, after thoroughly cleaning and steaming everything coming in contact with the milk, to introduce some good sour milk from a neighboring dairy. In this way the normal fermentation may be restored and the objectionable bacteria suppressed.

ROPY OR STRINGY MILK.

In this most troublesome fermentation the milk becomes what is commonly described as ropy or stringy. The milk is slimy and viscid. As this condition increases the milk may be drawn out into threads.

This fermentation should not be confused with garget, which appears in the fresh milk and is due to an inflammation of the udder. Ropy or stringy milk develops after the milk is drawn and is caused by the growth of certain kinds of bacteria. Although a number of kinds of bacteria causing this trouble have been studied as distinct varieties, it is probable that they are nearly all closely related. They do not form spores and are therefore destroyed by a comparatively low heat.

If a sample of ropy milk is examined under a microscope it is found to be filled with these small bacteria, each one surrounded by a capsule of a sticky, gummy substance. This gum or slime holds the bacteria together. When a thread is drawn out it is really a chain of bacteria held together by their sticky capsules.

Ropy milk is, so far as known, in no way detrimental to health. The famous Edam cheeses are nearly all made from milk which has undergone this fermentation. The peasants of Norway consider ropy milk a desirable beverage and bring about this fermentation by adding to fresh milk the leaves of certain plants on which the bacteria causing ropy milk are abundant. Most people, however, object seriously to milk with any tendency to form threads. This trouble frequently affects the milk of a dairy day after day and is removed only by the most drastic measures.

Outbreaks of this nature frequently occur in the cold months, because the bacteria of this group thrive better at low temperatures than the lactic-acid bacteria which hold them in check under normal conditions. In one case it was found that these bacteria were abundant in the dust of the stable. The trouble was removed by a thorough cleaning and whitewashing. In another serious and persistent outbreak it was found that the milk as it came from the dairy contained few or no ropy milk bacteria, but that they were abundant in the water tank in which the milk was held over night. The small amount of water occasionally splashed into the cans added sufficient bacteria to make the milk ropy in a comparatively short time. The utensils and floor had become so thoroughly impregnated with this organism that milk exposed in the room or strained through the wire strainer became ropy without contamination with the water. The trouble was removed by thoroughly scalding all the utensils, disinfecting the floor with a 5 per cent sulphuric-acid solution, and destroying the organisms in the ice water by adding potassium bichromate. This was used in the proportion of 1 part in 1,000 or, roughly, 1 ounce to 1 cubic foot of water.

The source of the trouble can sometimes be easily located by taking small samples of the milk in clean glass jars at different stages in the handling. These should be covered, set away in a cool place to retard the souring, and examined after 24 to 36 hours for indications of ropiness.

In dairies getting milk from a number of farms the source of the difficulty may be located on some particular farm and proper methods taken to remove the source of contamination.

Any precaution is almost sure to be ineffectual if all utensils coming in contact with the milk are not thoroughly scalded, or, better still, steamed.

MISCELLANEOUS FERMENTATIONS.

In addition to the various fermentations previously described, milk may undergo many other changes as a result of the action of bacteria or other micro-organisms. The color may be changed. The appearance of color in milk is due to the growth of bacteria which produce a pigment soluble in water. All the colors of the rainbow, from bright red to violet, are formed by bacteria. Blue milk, which is the most common of the color fermentations, is probably due to contaminations from water, in which the blue and violet forming bacteria are known to occur frequently. It is only under unusual circumstances that these bacteria occur in milk in sufficient numbers to give any trouble.

Milk sometimes undergoes an alcoholic fermentation, and in some countries this is brought about by proper inoculation and control of temperature to produce a beverage. The alcoholic fermentation is usually caused by a yeast which has the ability to break up milk sugar into alcohol and large quantities of carbon dioxid gas. The ordinary yeast, such as is used in bread making, produces similar changes in cane sugar, but does not affect milk sugar. In the alcoholic drinks made from milk the alcoholic fermentation is usually combined with an acid fermentation. Koumiss, a drink made originally in the Caucasus from mare's milk, is a combination of an alcoholic and a lactic-acid fermentation. This drink is believed to be beneficial in some diseases of the stomach and is frequently made from cow's milk. When made in this way with ordinary yeast it is necessary to add cane sugar.

Yoghurt, matzoon, or leben is a sour milk prepared in Turkey and neighboring countries with the so-called Metchnikoff bacillus to which reference has already been made. These various fermented milks are treated in more detail in Bureau of Animal Industry Circular 171.

DISEASE-PRODUCING BACTERIA IN MILK.

It is now generally recognized that many of the diseases which may be communicated from one person to another are caused by specific bacteria. The organisms causing some of these diseases have not yet been discovered, but the causal bacteria of many have been isolated and studied in detail. Some of these diseases occur usually only in human beings, others occur usually in animals and are only occasionally transmitted to men, while others may occur with equal frequency in both man and animals.

It is well known that certain diseases are sometimes disseminated through milk. By this means an epidemic may appear suddenly and last for a comparatively short time, or the infection may be continued for a long period and the development of the disease be so slow and obscure that the source is unknown.

Tuberculosis is an example of the latter class. So much in regard to this disease is still unknown, so many widely separated views are held, even by those most familiar with the subject, that it is impossible to make positive statements. However, tuberculosis has been studied in such detail that many facts have been well established, and many theories advanced are so probable that they can not be disregarded until they are disproved.

The question of the identity of tuberculosis of man with that of animals has been raised, and while it is not yet accepted as a fact by all investigators, a large majority of the people whose opinion has weight believe that the two diseases are identical. Assuming that they are, much difference of opinion exists as to the possibility of transmission from cows to man through milk. It is well known that other animals, including calves and pigs, may be infected by drinking milk from tuberculous cows, and the possibility that man, and especially children, may become infected in this way is so great that to disregard it on the ground that it is still unproved is carelessness approaching criminal negligence. The tendency among those who are studying the question most carefully is to consider milk as a serious source of danger.

A number of epidemics of diphtheria and scarlet fever have been traced to the milk supply. In diseases of this nature the milk is infected by some one suffering from an attack of the disease, or through some one who has been in contact with the patient. Obviously no one suffering from a contagious disease, or one who is caring for a diseased person, should be allowed to go near the stables or milk room or handle milk utensils. The only really safe way is to enforce strict quarantine against farms where contagious diseases are known to exist.

Typhoid fever, while not as contagious as some other diseases, is readily communicated from one person to another. The ordinary channel of communication is generally considered to be the drinking water, which may be contaminated by sewage, but occasionally it is disseminated through the food. Milk may become infected with this disease in various ways. Contaminated well or spring water may find its way into the milk through milk pails, cans, or bottles which were not thoroughly scalded after rinsing in cold water; the cans or bottles of milk may be left to cool in contaminated water and become inoculated by the accidental addition of even a few drops of water; the cows may wade in water or mud containing the typhoid bacillus and the small drops of muddy water which dry on the animal's flank may carry the organism to the milk; or flies may go directly from the waste from the sick room to the milk or milk utensils.

It has been demonstrated in the last few years that certain people may carry and give off from their bodies virulent disease-producing bacteria, even though they may be in good health. This is especially true of typhoid fever, and there is no doubt that dairymen have in many instances been the cause of serious epidemics without any outward evidence that they harbored the bacteria of the disease. Diphtheria and affections of the throat are also known to have been disseminated in this way.

In this connection must be considered the summer intestinal diseases of children. While the specific bacteria causing these troubles have not been recognized, it is generally accepted that they are carried by the milk and that this is the important factor in their control. It is evident that they are closely associated with the use of milk which contains large numbers of bacteria. It is reasonable to suppose that by the continued use of poor milk many of these bacteria lodge in the intestines and there produce substances of a toxic nature. It has been proved by careful observation and statistics that the death rate among babies in the crowded cities can be materially lessened by supplying them with good milk.

THE HANDLING AND CARE OF MILK.

Preventing changes in milk is a question of preventing the introduction of bacteria into milk and of checking their growth or destroying them when they are present. The production of milk reasonably free from bacteria is a simple question of cleanliness.

How far a milk producer can go in this direction with profit is a question that each one must decide for himself. The model dairies which are used as examples of what dairymen should do are frequently maintained in such an expensive manner that the farmer or dairyman doing a small business or producing milk in connection with other lines of farming can not expect to live up to their standards without increasing the cost of his milk.

However, there are many simple rules and methods for handling milk, requiring little extra labor and no added expense, which will materially increase the healthfulness and keeping quality of the product. Any precaution that reduces the dust in the stable at milking time reduces the initial number of bacteria in the milk. The cows should not be fed before milking. Cobwebs and other dirt can be easily removed from the ceiling. The stable floor should be so arranged that the dirt on the flanks and udders of the cows will be reduced to a minimum. The daily use of a brush will add greatly to the efficiency of these precautions. Care should be taken that the cows do not have to wade through filth in the barnyard.

Even with the greatest precaution some bacteria get into the milk, and further precautions must be taken to prevent their undue multiplication. The practical way to accomplish this is by control of the temperature of the milk. Advantage is taken of the natural law governing the limits and rapidity of growth of bacteria at different temperatures. The milk should be cooled at once to a temperature as near the freezing point as circumstances will permit. The usual limit is 50° F., but 40° F. is much more desirable.

The quickest and most economical method is to run the milk in a thin layer over the surface of a receptacle containing cold water. Many varieties of coolers for this purpose are on the market. Some are so arranged that a stream of water passes through them, while in others the milk flows over a conical tank containing cold water. It is not improbable, however, that in many cases the benefit derived from the cooling is overcome by the contamination of the dust on the cooler and the absorption of oders from the room in which it is used. A cooler should be located in a clean, well-ventilated room and be protected from dust by an efficient covering.

On farms where water is supplied by a windmill it is very easy to arrange the water trough so that the water flows from the pump through a trough or tank in which the cans of milk may be set to cool. This is a slow method, but much better than nothing.

It is not sufficient merely to cool the fresh milk. To insure good results it must be kept cold until used. The housekeeper who leaves her bottles of milk in the sun or standing in a warm kitchen should not blame the milkman for sour milk.

Various attempts have been made to preserve milk by holding it above instead of below the temperature favorable to the growth of bacteria. Devices for this purpose are called thermophores. While the most favorable temperature for many bacteria is at or near 98° F., few grow well at temperatures a few degrees above this point, and at 110° to 120° ordinary forms will not grow at all.

Milk held in thermophores usually will not curdle or change appreciably for several days, but it has been shown that unusual kinds of bacteria are able to develop at these high temperatures and that the milk which has every appearance of being good may contain large numbers of bacteria whose action is unknown. There are now on the market various bottles so constructed that the walls are almost perfectly insulated and thus permit only a slow change in the temperature of the contents of the bottle. Some of these have been recommended for holding babies' milk at the proper temperature for feeding through the night or on journeys. Nothing could be more pernicious, as the following table shows. In securing the results shown in this table a bottle of ordinary milk of good quality was divided, one half warmed to 102° F. and the other cooled to 36° F. These were put in pint vacuum-jacketed bottles and held in a warm room.

Growth of bacteria in milk held at feeding temperature.

Age of milk.	Temperature.	Bacteria per cubic centimeter.
Cold milk:	°*F.*	
Fresh	37	23,900
4½ hours	43	35,000
7½ hours	44½	46,000
Warm milk:		
Fresh	102	23.900
4½ hours	95	1,420.000
7½ hours	93	27,000,000

The large number of bacteria in the warm milk even at the end of 4½ hours makes the milk unsafe for infants' food. These bottles serve a very useful purpose when it is necessary to carry an infant on a journey, but they should be used only to keep the milk cold. When this is done the milk should be cooled by holding in a mixture of ice and salt until ice begins to form in the milk.

The next table shows the increase in temperature and bacteria in two samples of milk, one of which was properly cooled, while the other was only a little below the temperature of a good ice box. These two samples were held in pint vacuum-jacketed bottles and examined at the end of 24 and 48 hours:

Growth of bacteria in milk at low temperatures.

Age of milk.	Temperature.	Bacteria per cubic centimeter.
Inadequately cooled:	°*F.*	
Fresh	46.4	49,000
24 hours	64.4	2,140,000
48 hours	75.2	....
Thoroughly cooled:		
Fresh	23.0	29,000
24 hours	37.4	36,000
48 hours	57.2	124,000

The milk that was inadequately cooled was long past the limit of safety at 24 hours, while the thoroughly cooled milk was still in good condition, bacteriologically, after 48 hours.

Chemicals having an injurious effect on bacteria are sometimes used to retard the growth of bacteria in milk and thus prolong the time within which it may be sold. This practice is so universally condemned by public opinion that it need not be discussed here.

Heat is frequently applied to milk to destroy a part or all of the bacteria. Complete destruction of all bacteria in any substance is sterilization; pasteurization is a term used to designate a process of heating by which milk or other fluids are heated to destroy part, but not all, of the bacteria. Pasteurizaton may be by the "flash" method in which the milk, flowing in a continuous stream, is heated and cooled very quickly, or the "holder" process in which the milk after being heated is held or retarded so that the temperature is maintained 20 or 30 minutes.

The temperature of pasteurization, as it is ordinarily practiced, varies greatly. As a general rule, to insure good results, the temperature must be increased as the length of exposure is decreased.

When the milk is held 20 to 30 minutes the best temperature is 145° F. This is safely above the point at which the bacillus of tuberculosis is destroyed and below the temperature at which changes take place in the milk. Pasteurization at this temperature does not destroy all of the lactic-acid bacteria; consequently the milk will become sour before other bacteria have produced undesirable changes.

In the continuous machines, where the milk is maintained at the pasteurizing temperature usually for only 25 or 30 seconds, the temperatures used range from 160° F. to 185° F. The results at 160° F. are uncertain, and any temperature below this point has little or no beneficial effect. Milk may be efficiently pasteurized in the household by setting the bottle of milk in a vessel containing water, and heating the water until the milk reaches a temperature of about 145°. The bottle should then be taken from the water, wrapped in a towel and held 20 to 30 minutes. It should be then chilled at once and kept cold until used. Milk should in all cases be used within 24 hours after delivery.

Pasteurization should not be confused with sterilization. Even when the former is efficiently done many bacteria survive the heating and the milk must be properly cared for until it is used.

Milk may be sterilized by repeated boilings. This is usually accomplished by steaming on three or four successive days. After each boiling it should be held at room temperature for 24 hours to allow the spores to germinate and reach the vegetative stage. However, this method is by no means certain, especially if the milk contains a large number of bacteria, and to insure sterilization it is necessary to expose it to a temperature above the boiling point, which may be done in one operation by holding it in a closed chamber with steam under pressure.

Milk can also be sterilized by chemical means. The so-called "Buddeized" milk is sterilized by adding a small amount of hydrogen peroxid, which acts energetically on bacteria and is itself slowly decomposed into two harmless substances, oxygen and water. Milk treated in this way is said to be not entirely free from an objectionable taste and the sterilization is not always certain.

While bacteria are in no way essential to milk, they may be considered as normally present in milk, cream, ice cream, butter, and cheese. They may even occur in milk or its products in very large numbers without making it an unsafe food or in any way decreasing its food value.

Bacteria known to produce disease are seldom isolated from or counted in milk, and bacteriological counts should be taken merely as an indication of the way in which milk has been collected or the temperature at which it has been held. High numbers usually indicate insanitary conditions, careless handling, or old milk. However, milk may be collected under very poor conditions and the bacterial count held down by a liberal use of ice. On the other hand, milk collected in the most sanitary manner may in a few hours contain a large number of bacteria if it is held at a high temperature. Low counts may be due not to clean stables, and low temperatures, but to the use of antiseptics.

Every effort should be made by legitimate means to secure milk with a small number of bacteria, but milk or foods made from milk should not be indiscriminately condemned because they sometimes contain bacteria in numbers which are startling to those not familiar with the nature of these indispensable plants.

Issued April 16, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 491.

THE PROFITABLE MANAGEMENT OF THE SMALL APPLE ORCHARD ON THE GENERAL FARM.

BY

M. C. BURRITT,

Assistant Agriculturist, Office of Farm Management
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 1, 1912.

Sir: I have the honor to submit herewith a paper entitled "The Profitable Management of the Small Apple Orchard on the General Farm," which has been prepared by Mr. M. C. Burritt, Assistant Agriculturist in the Office of Farm Management of this Bureau.

This paper deals with the question of rejuvenating old apple orchards, which has been a subject of much inquiry. While the statistics used in connection with some of the discussions are compiled from data collected in a northern apple-growing region, the application of them is made from the standpoint of the problem in question and the fundamental principles involved.

As the subject matter covered by this bulletin falls within the province of Field Investigations in Pomology, the manuscript has been carefully revised and is submitted through the Office of Field Investigations in Pomology by Mr. A. V. Stubenrauch, Expert in Charge.

I recommend the publication of this manuscript as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
  The point of view 5
  The question 7
  The answer 7
Orchards it will not pay to renovate 8
  Scattered or very old orchards 9
  Poor varieties 9
  Unfavorable conditions 10
  Badly diseased trees 10
How to renovate an orchard 11
  Pruning 11
  Fertilization 15
  Cultivation 16
  Cover crops 17
  Spraying 18
Cost of renovation 19
Profits from renovated orchards 20
References on the subject of orchard renovation 21
Summary 21

ILLUSTRATIONS.

Page.
FIG. 1. The type of apple orchard it pays to renovate 6
2. A renovated orchard of four acres 6
3. Types of apple trees it usually will not pay to renovate 9
4. The wrong way to make a cut 12
5. The result of setting trees too close together and not thinning them out. 12
6. A tree which has been moderately headed back 13
7. An ideal to strive for in pruning and shaping an apple tree 14
8. A small but very profitable general-farm orchard near a large city in eastern New York 19

B. P. I.—728.

THE PROFITABLE MANAGEMENT OF THE SMALL APPLE ORCHARD ON THE GENERAL FARM.

INTRODUCTION.

Throughout the humid regions of the United States there are large numbers of small apple orchards. In many sections there is scarcely a farm which has not its small home orchard. These orchards vary in size from a few trees to several acres. They were planted mainly for the purpose of having a home source of supply of this excellent and popular fruit. In most cases they were not intended as commercial plantings nor was the fruit grown for sale. They were planted in order to have apples to eat during the long winter evenings, to make the famous apple pies, and to lay in a stock of sweet cider and vinegar.

Farmers of earlier days knew little of scientific orchard management and cared less. It was sufficient for them to know that the trees lived, grew, and eventually bore fruit. Not being a source of income, the orchard was naturally left to take care of itself. As a result, where the conditions were favorable some very good trees were grown, but where they were unfavorable the trees became stunted, scrubby, diseased, and unproductive. As a rule set too thick, they grew up in the air, the lower limbs died or were pruned off to get them out of the way, and high-headed, almost unreachable trees were the result. The trees usually stood in sod, and in most of these orchards the hay was cut and removed or the grass pastured off. In many places the regular rotation of crops was followed in the orchard. Too often it was planted on the poorest soil, site, and location on the farm and received little or no care. Is it any wonder that these orchards have become unprofitable, not to say unsightly?

THE POINT OF VIEW.

Conditions have changed. Markets, local and foreign, have opened up and are demanding apples and are willing to pay a good price for them. To meet this demand thousands of acres of orchards have been planted in many sections of the United States, but it will take time to bring these younger orchards into bearing. Meanwhile many men have turned to these old general-farm orchards in the hope that in their rehabiliment they may find profit in meeting this demand. If these old orchards can be rehabilitated they will at once (figs. 1 and 2) supply the market with needed fruit. Later, when the thousands of acres of newly planted trees come into bearing, it may be no longer profitable to maintain the old orchard in competition with younger and better orchards. Just at the present time, how-

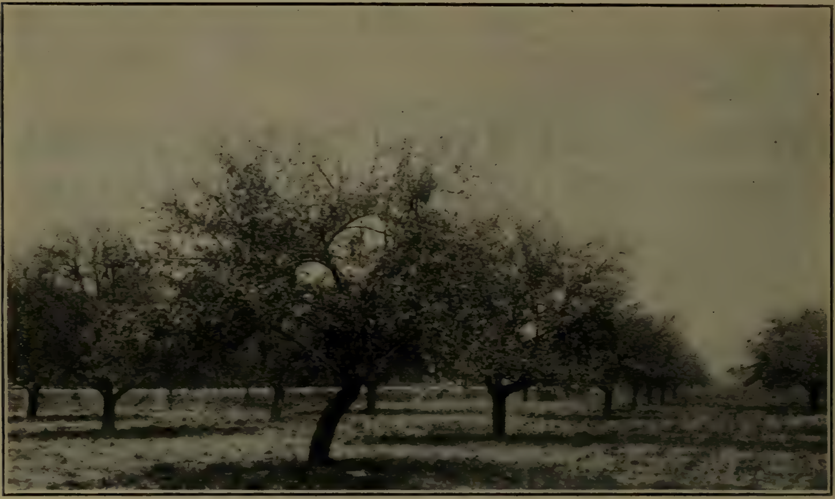


FIG. 1.—The type of apple orchard it pays to renovate. The trees are fairly young and vigorous and of good varieties. The orchard has been cropped in the regular rotation and has not been profitable. It could be made to pay in two years.

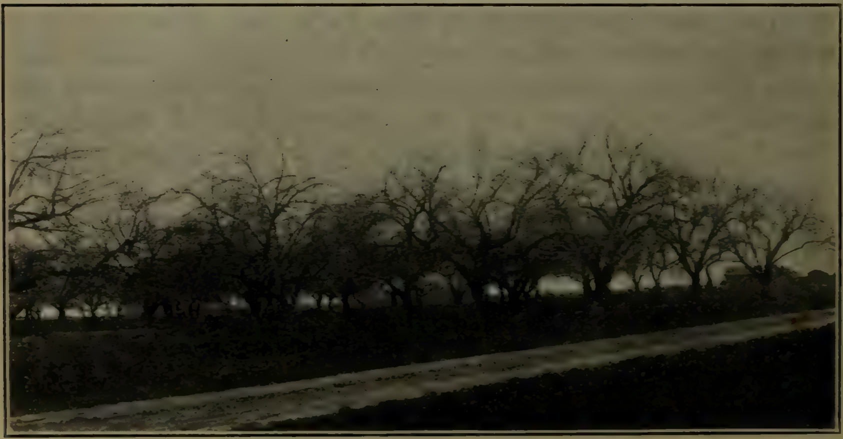


FIG. 2.—A renovated orchard of four acres which produced $1,100 worth of fruit the second year after renovation.

ever, the opportunity to make money out of the old general-farm orchard is good in many instances.

While there is such a thing as too great diversification, it is ordinarily true that those farms which have several important sources of income are the most profitable. The farmer who devotes all his energy to one crop, except it be a highly specialized crop, to the neglect of all others fails to come up to his possibilities. The aim on the general farm should be not so much to make one crop more profitable than the others, but to get the most possible out of every crop.

The old apple orchard, be it 20 trees or 200, may form an important source of income on the general farm. An effort should be made to make this unit a productive one and so to rejuvenate and care for these old trees that they will contribute as much as they are able to the net farm income.

THE QUESTION.

The question as to whether it will pay to rejuvenate these old trees is frequently asked of the Department of Agriculture. Will it pay to fix up my old orchard of 50 trees? What should I do to make my 3-acre orchard profitable? What can be done to get a better income from our small orchard, which has been neglected for years? What will it cost and what returns may be expected? These and many similar questions require an answer.

THE ANSWER.

The above question finds at least a partial answer in data gathered in western New York by the New York State College of Agriculture at Cornell University. In surveys made in several of the leading apple-producing counties of that section, data have been secured from about 11,000 acres of orchards. Tables I and II, compiled from these data, will give the reader some idea of what returns can be expected from the average well-cared-for orchard in western New York. And this section is representative of a large region of country. The greater part of these orchards are between 30 and 40 years old and many of them did not receive the best of treatment in their early life. In a sense they have been renovated, although the greater number of them never were as badly neglected as are many orchards in eastern, central, and southern New York and in New England.

These orchards show average yields per acre in different years of 50 to 225 bushels. The price in different years varies from 50 cents to $1 per bushel, probably averaging 75 cents. Thus it will be seen that a gross income ranging from $37.50 to $175 per acre may be depended on in most years. It should be pointed out that these figures were obtained from the most important commercial fruit-growing counties in the East and that they probably represent larger yields than can ordinarily be expected from a general-farm orchard. They are cited rather as possibilities which may be reached under the best methods of culture.

TABLE I.—*Number of orchards and acres surveyed in four counties in western New York from 1900 to 1908, with average yields.*[1]

County and year.	Number of orchards.	Area surveyed.	Average yield per acre.	County and year.	Number of orchards.	Area surveyed.	Average yield per acre.
Wayne County:		*Acres.*	*Bushels.*	Niagara County:		*Acres.*	*Bushels.*
1900	189	1,687	229	1902	125	1,415	236
1901	318	2,282	32	1903	273	2,736	197
1902	416	3,067	206	1904	459	4,321	195
1903	200	1,621	265	1905	372	4,152	155
				1906	173	2,031	179
4-year average	281	1,914	183	5-year average	280	2,931	192
Orleans County:							
1900	176	1,581	241	Monroe County:			
1901	212	1,972	63	1905	......	......	189
1902	356	3,195	248	1906	......	......	223
1903	485	4,345	224	1907	......	......	166
1904	283	2,869	284	1908	......	......	199
5-year average	302	2,792	212	4-year average	336	3,675	194

[1] From the orchard surveys of Wayne, Orleans, and Niagara Counties, Bulletins 226, 229, and 262, respectively, Cornell University Agricultural Experiment Station. Monroe County survey not yet published.

TABLE II.—*Average yield in bushels per tree in three counties of western New York from 1900 to 1906. Trees mostly 30 to 45 years old.*[1]

County.	Year.							Average yield.
	1900	1901	1902	1903	1904	1905	1906	
Wayne	5.8	0.8	5.0	......	......	......	......	3.3
Orleans	5.8	1.5	6.0	5.4	6.8	......	......	4.6
Niagara	......	......	6.6	5.0	4.7	4.6	4.4	4.8

[1] From the orchard surveys of Wayne, Orleans, and Niagara Counties, Bulletins 226, 229, and 262, respectively, Cornell University Agricultural Experiment Station.

The answer is plain but must be qualified. In most cases it probably will pay to renovate the old farm orchard. In some cases it will not pay. First, let us see what classes or kinds of orchards it will be unprofitable to try to renovate and eliminate these. Then we may proceed to outline the steps to be taken in making the orchard profitable.

ORCHARDS IT WILL NOT PAY TO RENOVATE.

Those orchards on which it probably will not pay to spend much money or effort may be put into four classes:

(1) Orchards with less than 50 per cent of a stand of trees, especially when they are more than 40 years of age (fig. 3).

(2) Orchards with poor or undesirable varieties.

(3) Orchards on a poor or unsuitable soil or in an unfavorable site or location.

(4) Orchards in which the trees are badly diseased and show very few signs of vigor.

SCATTERED OR VERY OLD ORCHARDS.

When the trees in an orchard do not occupy more than 50 per cent of the land it usually will not pay to cultivate all the land for these few unless the 50 per cent be very regularly distributed over the land. It is not as a rule advisable to fill in an old orchard with younger trees. Sometimes, however, this may be done if trees are not too old and where rapid-growing and early-bearing trees, such as Wealthy, Oldenburg (*Duchess of Oldenburg*), Yellow Transparent, and Wagener, are used. When trees are older than 35 to 40 years the chances of successful renovation are very much less. Older trees should be in exceptionally good condition if renovation is to be attempted, as it is much more difficult to infuse vigor into old trees than into younger ones.

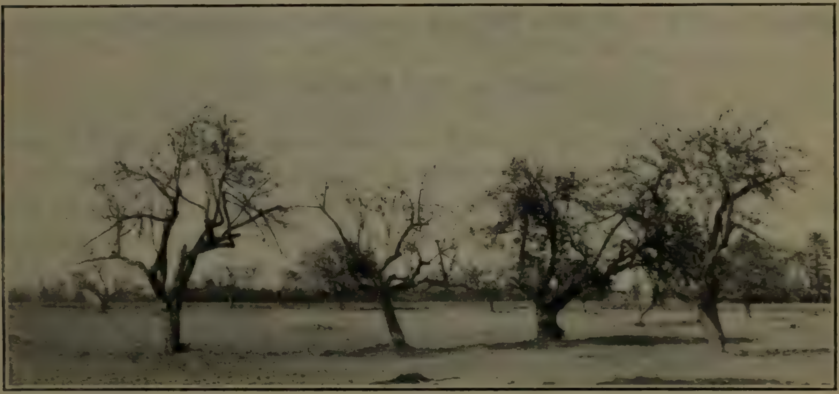


FIG. 3.—Types of apple trees it will not usually pay to renovate. They are too old, lack vigor, and are more or less diseased.

POOR VARIETIES.

It usually will not pay to renovate orchards composed largely of worthless or very poor varieties. Nothing is to be gained by increasing the yield or grade of a variety which can not readily be sold in the open market at a good price. When trees of such varieties, however, are not too old—not more than 30 years—and are in fairly good vigor, they often may be top-worked to advantage. The best method of doing this is by cleft-grafting in early spring. Under favorable conditions a tree may be changed from a poor variety to a desirable one and made to bear fruit in from 3 to 5 years.[1]

There is some question as to whether it will pay to renovate summer apples in the Northern States. To make renovation of these trees profitable requires either a good demand in the local market or exceptionally good transportation to and demand in a more distant market. Much the same is true of odd or uncommon varieties.

Some of the characteristics which make a variety poor are unattractiveness in shape, size, or color; inferior quality; lack of hardiness in tree or fruit, making them subject to disease; small production; and being comparatively unknown in the markets and therefore not in good demand. To make a variety worth renovating, then, it should be fair to good in quality; attractive; a fair or, better, a prolific producer; a good keeper and shipper; and in good demand at good prices in the market. All these factors should be considered before renovation is attempted.

UNFAVORABLE CONDITIONS.

An apple orchard set on a wet soil which can not be readily drained is worthless. Trees set on poor soils require too much fertilization to get them in shape to allow of much profit. Trees growing on soils that are too dry or leachy are less amenable to renovation. In like manner orchards located in frost pockets, at elevations too low or too high, on sites too much exposed, or on slopes too warm or too cold will not pay returns on the money spent in renovating them equal to the returns from those better situated. The renovation of orchards at a considerable distance from the railroad, with poor highways and poor shipping facilities, and in isolated and inaccessible places will not prove as profitable as the renovation of orchards in better locations. In short, orchards in sites or locations which are naturally unfavorable to apple growing will be more expensive to renovate and less profitable in the end, and, in fact, may not give any profitable returns because of these adverse conditions.

BADLY DISEASED TREES.

It costs considerably more to renovate a badly diseased orchard than one not so diseased. All disease must be eradicated by destroying infected parts and by spraying. Dead branches and limbs must be removed and the effect may be to seriously and permanently weaken the tree. Disease frequently stunts the growth to such an extent as to make it impossible to rejuvenate the tree. If vigor has been lost, no amount of stimulation will restore it. Good vigor, even though it be dormant, is absolutely essential in a tree if it is to be improved. Trees which have been frequently defoliated by scale or canker worms or in which apple-tree canker and rot have obtained a strong foothold are expensive to rejuvenate and less satisfactory when rejuvenated.

---

[1] For complete directions as to methods, time, etc., see Farmers' Bulletin 113, "The Apple and How to Grow It," and Yearbook, U. S. Department of Agriculture, for 1902, pp. 245–258, "Top-Working Orchard Trees," both of which may be obtained free on request to the Secretary of Agriculture, Washington, D. C.

HOW TO RENOVATE AN ORCHARD.

Four important steps must be taken in the improvement of the general-farm orchard. These steps are practically the same as those which would be employed in the average orchard under normal conditions. With but little modification, the methods to be outlined may be continued after renovation. These are: (1) Pruning, (2) fertilization, (3) cultivation, and (4) spraying.

A general outline of work or a plan of campaign may be briefly summarized as follows, details being given later on:

(1) If the orchard is and has been in sod for a number of years, plow in the fall about 4 inches deep. If not, plow either in late fall or early spring.

(2) During the winter put on from 12 to 15 loads of barnyard manure per acre, or 1 load to from 3 to 5 trees. Another plan is to apply in the spring 100 to 200 pounds of nitrate of soda, 300 to 500 pounds of acid phosphate, and 150 to 300 pounds of sulphate or muriate of potash.

(3) In the winter or in early spring before growth starts, cut out all dead and diseased wood from the tree, head back the highest limbs, and thin the branches to admit sunlight.

(4) Apply 1,500 to 2,000 pounds of lime per acre and work it and the manure or fertilizer into the soil thoroughly with a disk harrow or spring-tooth harrow. Keep up this cultivation until midsummer.

(5) After cultivation ceases for the season, sow a cover or green-manure crop to plow under the following spring. Clover is one of the best leguminous crops in the North, while cowpeas are widely used in middle latitudes and in the South. For a nonleguminous crop rye is the most extensively used, though buckwheat is commonly used in some sections of the North.

(6) Spray the trees in accordance with the directions given in Government and State publications on this subject.

PRUNING.

Pruning is an early and important step. This operation has several distinct purposes, all of which should be kept well in mind.

Its first object will be to remove dead or injured wood. In doing this the cut should be made well behind the injured or diseased part and the wound should be left with smooth edges. (Fig. 4.)

The second object will be to shape the tree. If it is too high it should be headed back. It is most important to get the trees down low enough so that the operations of spraying and pruning can be easily performed. (See figs. 5 and 6.) It will be found very necessary to do this heading back on most old orchards, as usually the

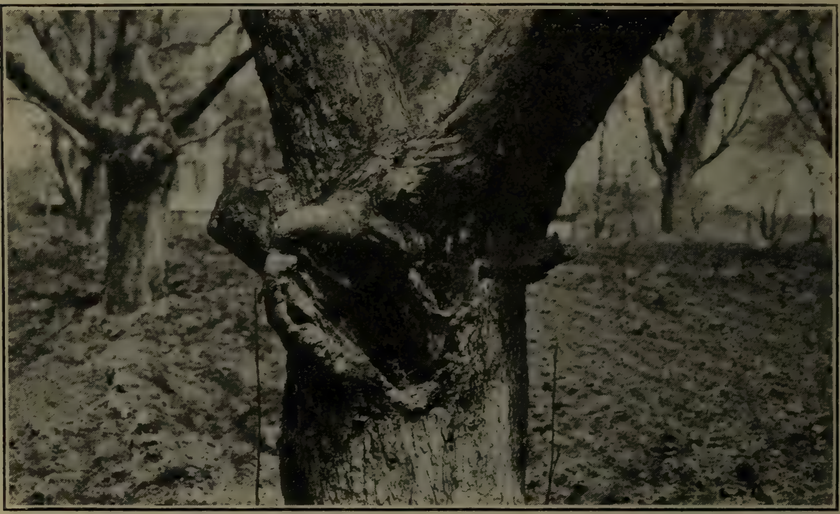


FIG. 4.—The wrong way to make a cut. The limb was cut off too far from the body of the tree and has rotted clear into the trunk.

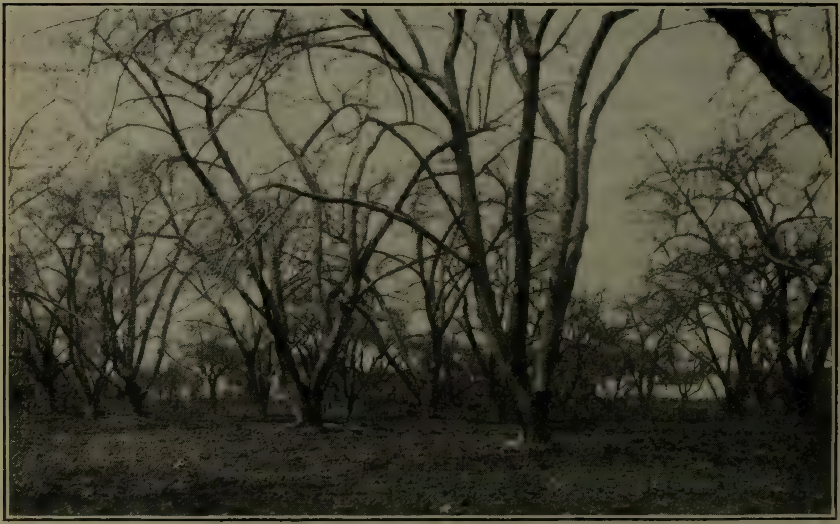


FIG. 5.—The result of setting trees too close together and not thinning them out. The crowding of the trees has forced them to grow up in the air and has made the orchard look like a piece of timber. Still this orchard has been renovated and averages an income of $150 per year. It hardly pays to head back trees as old and as large as these.

trees have been set close together, "trimmed up," and left to grow as high as they would. Most old orchards are much too high, a defect due both to too high heading in the first place and too high training subsequently. Five or ten feet may be safely removed if the work is properly done and good judgment used, cutting back the leaders of the uppermost branches and not cutting too much out of a tree in one year. (See fig. 7.)

In the third place, it will usually be necessary to thin out the smaller branches and in many cases even the larger limbs in order to admit plenty of sunlight to the leaves and fruit and to avoid too great competition among the branches. Thinning the branches thins the fruit also, enabling the fruit which remains to develop better than it otherwise would.

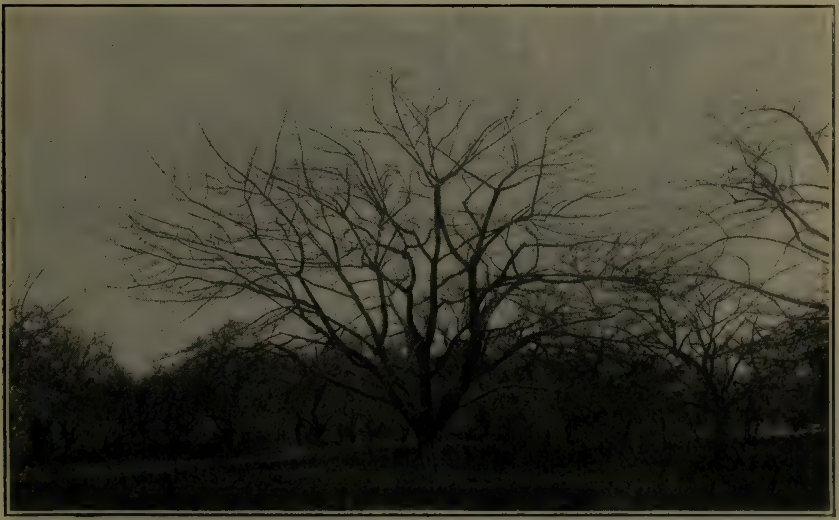


FIG. 6.—A tree which has been moderately headed back. Note that the leaders in the top of the tree have been removed, encouraging the growth of lateral branches. Note also the clean tillage.

Pruning during the winter or dormant season tends to stimulate growth and to make the tree more vigorous. This stimulation is often a very important result of early pruning; in fact, it is often essential thus to induce new vigor in the tree. Pruning may be done at any time during the dormant season, though it is best done in early spring just before the buds swell or growth starts.

All large wounds, or those over 2 inches in diameter, should be painted over with a coat of some such material as a heavy lead paint, which is probably best for the purpose, adding a little lampblack to make the color inconspicuous. This treatment excludes moisture and consequent decay and disease. If a tree has a bad crotch which is splitting down, a half-inch or 1-inch iron bolt with a wide, thick washer at either end may be used to draw and hold the parting branches together. Such bolts are inserted through holes bored in the limbs. A limb that has rotted badly on one side or in the middle may be strengthened and the rot prevented from spreading by cleaning out the rotted portion thoroughly, disinfecting the bare surfaces, applying some such material as tar to form a waterproof layer, and filling the cavity with cement.

It may sometimes be necessary to remove some trees. Poor or unknown varieties are usually better cut down unless they can be topgrafted. Mature trees that are 30 by 30 feet apart or closer, as in many old orchards, are too close for profit. It is usually advisable to cut out the even or the odd trees in alternate rows in order to give the trees plenty of room to grow and the operator room to spray, cultivate, and pick the fruit.

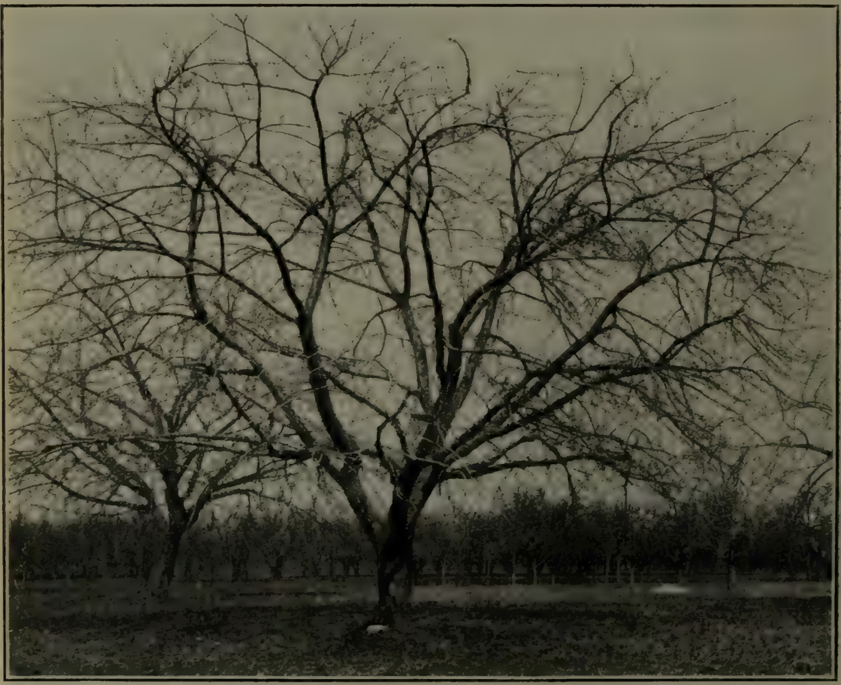


FIG. 7.—An ideal to strive for in pruning and shaping an apple tree. Note the distribution of the branches. This tree has produced as high as 20 barrels of fine fruit in one season and averages about 10 barrels per year.

The saw is the best all-around tool to use for pruning. It can conveniently be used for practically all cuts, and with it the edges will be made smooth. Shears and extension pruners may be used, but such tools are not generally so useful as the saw. Shears with handles about 2 feet long are more convenient than the saw for heading back small limbs and for thinning out the ends of branches. An excellent type of saw is one about 20 inches long, about 4 inches wide at the butt, narrowing to about 1½ inches at the point, thick enough to be rigid, and with but one cutting edge, which should always be kept sharp.

FERTILIZATION.

Most general-farm orchards have been left in sod for many years and are in sod at present. Many are cropped in the regular rotation and the crops removed from the land. In most cases no effort has been made to feed the trees or to keep up the fertility of the soil.

Apples are as much a crop as anything grown on the farm and should be so regarded. If the trees are not taken care of a farmer has no reason to expect that they will give good yields. When more than one crop is grown on the same land without extra care, fertilization, etc., good yields of both may not justly be expected. When this practice has been in vogue on a farm it may be expected that the orchard will be lacking in fertility. The growth of the trees will usually indicate the fact. If the tree looks scrawny and stunted and if examination shows either that no growth or but a few inches of annual growth are being made, it is certain that fertilization is one of the necessary requisites for rejuvenation.

The necessary plant food is best supplied by barnyard manure applied at the rate of 10 loads per acre for a light application or 20 loads for a heavy application. This amounts to a load for each two to five trees. Such an application will not only go far toward supplying the necessary nitrogen, phosphoric acid, and potash, but especially, of course, will add humus and help to improve the physical condition of the soil. Manure should be applied in the fall after plowing or during the winter, except on land that washes badly. It should not be piled near the trunk of the tree, but should be spread uniformly over the entire surface of the ground. It is particularly essential to spread the manure under and beyond the farthest extent of the branches, as the most important feeding roots penetrate this area.

Nitrogen produces strong wood growth, which is desirable on old trees not growing vigorously. It is easily possible to overdo the use of nitrogen and produce wood growth at the expense of fruit buds and fruit. Potash and phosphoric acid are found in larger proportions in the leaves and fruit. Good, vigorous twig growth, an abundance of large dark-green leaves, and fruit of good size are the most satisfactory proof of sufficient fertility.

Manure will usually supply the needed elements in sufficient quantity, if a medium to heavy application can be made. But if it can not be obtained commercial fertilizers may be resorted to. For the first year about 200 pounds of nitrate of soda or 300 pounds of dried blood per acre should be applied broadcast in early spring and thoroughly worked into the soil with the spring-tooth harrow. It is well to apply the nitrate of soda in two applications a few weeks apart, especially on soils which are leachy and in wet seasons, as part of the nitrogen may leach away if it is all applied at once. It should also be applied a little later than the other fertilizers after growth has started. After the first year leguminous cover crops should be depended on for nitrogen. Then from 200 to 400 pounds of treated rock phosphate or basic slag and the same amount of sulphate or muriate of potash[1] should be used to furnish the other two elements. Thus a large amount of available plant food will be supplied to the tree and should result not only in better wood growth, but in the formation of vigorous leaf and fruit buds for the following year.

Lime is not usually a true fertilizer, except on soils markedly deficient in lime. It will usually be advisable to apply from 1,500 to 2,000 pounds of fresh-burned lime, or its equivalent, per acre in order to correct natural soil acidity, if there be any, to hasten the decay of organic material, to increase the activity of the soil bacteria, and to improve the physical condition of the soil by flocculating the soil particles and breaking up lumpy soils. Lime also helps to liberate plant food by recombining it with certain other elements. After this first heavy application of lime an additional 800 pounds may be applied about every four or five years.

CULTIVATION.

If an old apple orchard is in sod, especially if the sod is an old or stiff one, it should be plowed in the fall. Ordinarily, fall plowing is good practice in most orchards, but in cases where the soil is very loose and liable to wash and expose the roots to freezing, or where it is very heavy and apt to puddle when exposed to the weather, or in very cold climates where the snowfall is light, it is best to plow in spring. By turning under the grass, rubbish, etc., in the fall the process of decay and incorporation with the soil is hastened. A soil often becomes deadened or lifeless from long inertia, and when exposed to the action of moisture and frost its physical condition will be improved. A disk harrow may often be successfully used for the first breaking up of this sod preparatory to plowing.

It is never advisable to plow deeply in old orchards. Plowing should be only deep enough to turn under grass and other litter and cover it with soil. This depth will be from 3 to 5 inches, 4 being a good average and about right. It is always impossible to plow any old orchard which has long been down in sod without breaking a great many of the roots, which, of course, will be close to the surface, but it is desirable to break as few of these roots as possible; hence the necessity for shallow plowing. However, the danger of breaking roots should discourage no one from plowing, as the benefits derived under such conditions are many times greater than the damage done.

---

[1] Results obtained at the Massachusetts Agricultural Experiment Station and at the Pennsylvania State College Agricultural Experiment Station would indicate that sulphate is better than muriate of potash. See "Manuring the Apple Orchard." Twenty-Second Annual Report of the Massachusetts Agricultural Experiment Station, 1910, p. 10; also "Fertilization of Apple Orchards," Bulletin 100, Pennsylvania State College Agricultural Experiment Station.

After fall-plowing a stiff sod, the best tool to use in the early spring to loosen up the surface soil and to work in any manure which may have been applied during the winter is the disk harrow. In very loose and open, deep soils the spring-tooth harrow will answer for this purpose, though not as well as the disk, which is the most effective implement, especially where there is a very stiff sod to be broken up or much coarse litter is on the surface. Still it will do very satisfactory work and on stony land is better than the disk harrow. The orchard should be gone over several times with one of these tools during the first month in which it is possible to get on the land, the sooner after growth starts the better.

After the soil has been worked into a fine mechanical condition, subsequent cultivation will be done largely in order to maintain a surface mulch to prevent the loss of moisture by evaporation and incidentally to kill and keep down weeds. For this purpose the spring-tooth harrow should be set more shallow or, better still, the spike-tooth or smoothing harrow should be used. The orchard should be gone over once in ten days or two weeks or after hard rains which form a crust.

COVER CROPS.

About the middle of July or the first of August cover crops should be sown. These are of two kinds, leguminous and nonleguminous. Of the former the clover and hairy vetch for the North and cowpeas and soy beans for the middle and southern latitudes are perhaps the best. Hairy vetch is also sometimes used in the South. Of the nonleguminous cover crops rye is the most widely used, though in some sections, particularly in the North, buckwheat serves the purpose well.

The leguminous crops, besides being of value for the humus which they supply, add nitrogen to the soil. In fact they form the cheapest source of that element of plant food. In general they are the most desirable cover crops to use in an old orchard, although their use may possibly be overdone in young orchards. If the cover crop can be sown before the middle of July, red clover is probably best in the North, while cowpeas hold a relative position in warmer sections.

In seeding, from 12 to 15 pounds per acre of red clover should be used and sown broadcast, being covered with the smoothing harrow. One bushel of cowpeas per acre is a fair rate of seeding for that crop. They are usually sown broadcast. If it is impossible to sow the cover crop before the middle of July, especially in the North, hairy or winter vetch is better, because it grows later in the season than clover, which in the North will not usually make sufficient growth to pay if sown after the first of August. About a bushel of vetch seed per acre is required, making the seeding expensive.

If nonleguminous crops are to be used, rye is an excellent crop where it is not too much shaded. In may be sown any time between July 15 and October 15. In the warmer sections of the country, rye should not be sown too early when wanted as a winter cover crop, otherwise in the long season of growth which follows it will reach too great a degree of maturity. It grows rapidly and quite rank late in the fall and early in the spring and is very hardy. Two bushels of seed are required per acre. Buckwheat is nearly as good and may be sown up to September 1. It does not produce quite as much growth as rye, but grows even more rapidly. A bushel of seed per acre is sufficient. Neither of these crops adds plant food to the soil as do the legumes nor are their root systems as deep or extensive, but they probably produce more humus-forming material in a short time than clover. When good vigor is established in the apple orchard, leguminous and nonleguminous cover crops may be alternated, or they may be sown together. For the first few years, however, leguminous crops should be used. When sown together use a little more than half the regular seeding of each. The use of winter cover crops of course necessitates spring plowing.

SPRAYING.

It is always advisable and usually absolutely necessary to spray the old apple orchard. Not all diseases can be removed from the tree itself by pruning. An efficient spray thoroughly applied is needed to complete the renovation. Moreover, spraying is an insurance against disease or insects which may attack the fruit during the current season. It is seldom possible to produce absolutely clean fruit without spraying.

Sprays may be applied with any of several hand pumps well suited for the purpose and costing, with barrel, hose, nozzle, and all necessary attachments, from $20 to $50. Traction outfits used for spraying potatoes may be utilized with fair success on small orchards. If the orchard is larger than five or six acres it may pay to purchase a gasoline engine and outfit or a compressed-air outfit, especially where these outfits can also be utilized for other purposes.

COST OF RENOVATION.

The cost of the renovation described will be considerable, but no greater than the returns will warrant. The estimates shown in Table III have been carefully made from records obtained on several farms in New York State (fig. 8). The figures show the probable minimum and maximum cost per acre for the first year.

FIG. 8.—A small but very profitable general-farm orchard near a large city in eastern New York. The renovation of such old orchards near good local markets offers excellent opportunities for success.

TABLE III.—*Estimated cost of first year's work in renovating an old orchard.*

Item.	Estimated cost per acre.	
	Minimum.	Maximum.
Plowing	$2.00	$3.00
Manure, 10 to 20 loads, at $1, or its equivalent in commercial fertilizer	10.00	20.00
Hauling manure, average, at 50 cents per load	5.00	10.00
Pruning and hauling brush	5.00	10.00
Disking or harrowing twice	1.00	1.50
Disking or harrowing third or fourth time	.50	1.00
Cultivation, 2 to 4 times	.50	1.00
Spraying once:		
Material	2.00	4.00
Labor	1.00	1.50
Total	27.00	52.00

For each additional spraying after the third, the cost should be increased correspondingly; that is, $1.50 to $2.50 per acre should be added.

It will thus be seen that the probable cost of the first year's work will be from $30 to $57 per acre, according to circumstances. On account of the shock to the tree of sudden change of treatment and because of the insufficient time for its good effects, the income the first year will probably be very small and possibly nothing at all. After the first year, however, the income should increase each year to its maximum as the good effects of the treatment are obtained. It is, of course, evident that the cost and profit will vary with the thoroughness of the treatment, the number of trees per acre, and similar variant factors.

PROFITS FROM RENOVATED ORCHARDS.

Table IV gives the accurate record of a 6.1-acre orchard for eight years and will give the reader a good idea of the expense, income, and net profit on an average orchard in western New York for the period. The average yield during the eight years was 67 barrels per acre, which sold for an average price of $2.33 per barrel. Culls and drops made up the remainder. The average cost of production was $1.16 per barrel.

The expense included not only the usual items in the cost of production, such as pruning, cultivation, spraying, harvesting, marketing, etc., but land taxes, 5 per cent interest on the investment in equipment and on the land investment at $150 per acre.

About one-half of the trees are 36 years old. The remainder are over 50 years old. The varieties are principally Baldwin, Twenty Ounce, and Tompkins King. The younger trees are set 32 by 32 feet, the older 28 by 56 feet (one-half having been cut out), and many trees are missing in both blocks. The orchard contains 243 mature trees.

TABLE IV.—*Income, expense, and net profits on a 6.1-acre apple orchard in western New York.*

Year.	Income.		Expense.		Net profit.	
	Total.	Per acre.	Total.	Per acre.	Total.	Per acre.
1902	$913.87	$149.81	$519.39	$85.15	$394.48	$64.66
1903	969.89	159.00	482.56	79.11	487.33	79.89
1904	559.40	91.70	360.39	59.08	199.02	32.62
1905	792.25	129.87	324.31	53.16	467.94	76.71
1906	818.76	134.22	401.80	65.87	416.96	68.35
1907	861.45	141.22	364.40	59.74	497.05	81.48
1908	1,362.97	223.44	583.55	95.67	779.42	127.77
1909	1,896.79	310.95	591.93	97.03	1,304.86	213.92
1910	1,008.44	165.32	399.77	65.54	608.67	99.78
9-year average	1,020.42	167.28	447.57	73.38	572.85	93.93

A characteristic example of orchard renovation is the case of a farmer in Monroe County, N. Y. A 4-acre orchard over 50 years old containing about 120 trees, mostly Baldwins (nearly half of the trees had died), had had no care whatever for at least 20 years to the writer's certain knowledge. The largest income ever obtained from this old orchard in its best year was $400 and the average income was probably less than $100.

Two years ago this farm changed ownership. The new owner was a good orchardist and began operations to renovate the orchard at once. Seventy-five loads of stable manure were applied and plowed under and the most thorough cultivation was practiced. About one-fourth of all the wood in the trees was removed and the trees were thoroughly sprayed.

The first year not more than $25 worth of fruit was sold, but the second year the response to better methods was $1,100 worth of fruit. Pruning has cost about $50, plowing and cultivation $75, spraying $60, and fertilization $100, a total of $285, leaving a net profit for the first two years of operating of $840, or $210 per acre.

REFERENCES ON THE SUBJECT OF ORCHARD RENOVATION.

Those who care to pursue this subject further, or who desire to obtain more detailed information, particularly such as refers to the respective States, will find excellent material in three State experiment station bulletins:

Bulletin 253, Experiment Station of Michigan Agricultural College, "Can the General Farmer Afford to Grow Apples?" contains many valuable suggestions on improving apple orchards, together with some figures on the cost of renovation.

Bulletin 180, 1907, Ohio Agricultural Experiment Station, "Renewal of Old Orchards," is profusely illustrated with many excellent views of renovation methods.

Bulletin 61, part 2, Connecticut Agricultural Experiment Station, "Renovation of Old Apple Orchards," is invaluable for New England conditions and is also well illustrated.

SUMMARY.

(1) A large proportion of the farms in the older regions of the country have small apple orchards on them.

(2) These orchards should be made to produce a proportionate share of the income on the general farm.

(3) The present demand for apples makes it profitable to renovate many of these old orchards.

(4) The orchards it probably will not pay to renovate are those with but a few scattered old trees, with poor varieties, located unfavorably, or with many badly diseased trees.

(5) There are four principal steps to be taken in renovating an orchard. These are (*a*) pruning, (*b*) fertilization, (*c*) cultivation, and (*d*) spraying.

(6) Pruning should follow along the line of certain fundamental principles and with definite ends in view.

(7) Fertilization is very important in renewing old orchards, which are usually low in fertility. Manure is best for this purpose.

(8) Cultivation is very important. Clean culture until midsummer, followed by a cover crop of clover, hairy vetch, cowpeas, rye, buckwheat, or some other crop which is known to be of local value, is a practice usually to be recommended.

(9) Spraying is absolutely essential to the production of good fruit.

(10) Renovation costs from $30 to $57 an acre.

(11) Income varies with conditions, but may be expected to be well in advance of the cost after the first year.

(12) Examples cited show that a much greater profit can be obtained from many of these old orchards than from ordinary farm crops.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

O

Issued April 24, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 492.

THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

BY

A. L. QUAINTANCE,
Of the Bureau of Entomology,

AND

W. M. SCOTT,
Of the Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Washington, D. C., February 3, 1912.

Sir: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "The more Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple," by A. L. Quaintance, of the Bureau of Entomology, and W. M. Scott, of the Bureau of Plant Industry.

During the past few years the summer spraying of apple orchards has undergone important improvements, and many questions of detail have thus been raised in the minds of growers. The present paper, based upon results of the department's investigations of the subject during the past several years, is intended to answer these questions and to furnish information which will enable the orchardist to obtain the maximum benefits for his outlay in time and money in spraying operations.

Respectfully,

L. O. Howard,
Chief, Bureau of Entomology.
B. T. Galloway,
Chief, Bureau of Plant Industry.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

- Introduction 5
- The codling moth 5
  - Character of injury 6
  - Number of generations 7
  - Description and life history 7
    - How the insect passes the winter 7
    - The moth 7
    - The egg 8
    - The larva 9
    - The pupa 9
  - Treatment 9
    - First application 9
    - Second application 10
    - Third application 10
- The plum curculio 11
  - Character of injury 11
  - Period of oviposition and number of eggs laid 13
  - Time required for transformation from egg to adult 13
  - Can the curculio be controlled by sprays? 14
- The lesser apple worm 16
- Cankerworms 17
  - Treatment 19
- The bud moth 20
  - Treatment 21
- The apple-tree tent caterpillar 21
  - Treatment 22
- The San Jose scale 22
- Apple scab 23
  - Economic importance 23
  - Distribution 23
  - Character of the injury 24
  - The fungus causing the disease 24
  - Treatment 25
- Bitter rot 26
  - Economic importance 26
  - Character of the injury 26
  - Cause of the disease 27
  - The limiting factors 27
  - Treatment 28
- Apple blotch 29
  - Character of the injury 29
    - On the fruit 29
    - On the twigs 30
    - On the leaves 30
  - Cause of the disease 30
  - Infection period 31
  - Treatment 31
- Cedar rust 31
  - Character of the injury 32
  - Life history of the cedar-rust fungus 33
  - Infection period 34
  - Treatment 34

Page.
Apple leaf-spot ... 35
  Cause of the disease ... 36
  Treatment ... 36
Sooty fungus and flyspeck ... 36
  Treatment ... 37
Preparation and use of sprays ... 37
  Lime-sulphur solution ... 38
    Uses ... 38
    Home-boiled lime-sulphur solution ... 38
    Commercial lime-sulphur solution ... 40
  Bordeaux mixture ... 40
    Directions for making ... 41
  Arsenate of lead and other arsenicals ... 42
Schedule of spray applications ... 43
  First application ... 44
  Second application ... 44
  Third application ... 44
  Fourth application ... 44
  Fifth application ... 44
  Sixth application ... 44
  Apple-blotch treatment ... 44
Equipment for spraying ... 45
Applying the spray ... 46

ILLUSTRATIONS.

Page.
Fig. 1. The codling moth larva (*Carpocapsa pomonella*) and its work ... 6
2. Stages of the codling moth ... 8
3. Apple clusters, showing young fruit with calyx lobes spread and in right condition for spraying; apples with calyx lobes closed and too late for satisfactory spraying ... 10
4. Egg scars of the plum curculio (*Conotrachelus nenuphar*) on young apples ... 11
5. Duchess apples at picking time, showing deformed condition from egg and feeding punctures of the plum curculio ... 12
6. Fall feeding puncture of the plum curculio in ripe apple ... 12
7. Injury by the lesser apple worm in calyx basin and end of a ripe apple. 16
8. Injury by lesser apple worms to apples after barreling ... 17
9. Spring cankerworms ... 18
10. Work of the spring cankerworm (*Paleacrita vernata*) on apple ... 19
11. Nest and larvæ of the apple-tree tent caterpillar (*Malacosoma americana*) ... 21
12. Baldwin apple badly infested with the San Jose scale (*Aspidiotus perniciosus*) ... 22
13. Apples affected with the scab fungus ... 24
14. The scab fungus on apple leaf ... 25
15. Apple affected with bitter rot ... 26
16. Maiden Blush apple affected with apple blotch ... 30
17. Foliage of York Imperial apple affected with cedar rust ... 32
18. Cedar rust disease on the apple ... 33
19. Cedar rust disease on the cedar. (Cedar apple) ... 34
20. Apple leaf-spot on leaf of Ben Davis apple ... 35
21. Sooty fungus and flyspeck on the Huntsman apple ... 37

THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

INTRODUCTION.

The spraying of apple orchards has received a great impetus during the past few years by reason of the increased demand for good fruit and the satisfactory prices received therefor. While most commercial orchardists have been spraying for a good many years, the practice has not been as general among small orchardists as is desirable, and the present profitableness of apple culture has been the principal factor in awakening an interest in a crop heretofore much neglected by them.

A few years ago it was felt that orchard spraying was on a rather definite basis, but recent improvements in spray materials and apparatus for their application have contributed to raise many questions of detail in the minds of fruit growers. These questions have to do with the best spray to use; times of making applications; grade of chemicals to purchase; the desirability of preparing sprays at home in preference to use of commercial preparations, etc.

It is the aim of the present paper to furnish the orchardist necessary information for summer spraying, or spraying trees in foliage, as opposed to treatments during the dormant period of trees, as for the San Jose scale, blister mite, etc. The principal insects and diseases affecting the fruit and foliage of the apple are first considered, and with the illustrations should be easy of recognition. This is followed by a consideration of the sprays recommended, and directions for their preparation and use. Owing to the extended area in the United States over which the apple is cultivated, it is necessary to refer to certain insects and diseases which are of interest in more or less restricted localities, and to indicate the appropriate treatment for the same in the sprays schedule. It is believed, however, that the orchardists in the New England States, as well as the orchardists in the Ozark regions of Arkansas and Missouri, will have no difficulty in determining the particular applications necessary under their respective conditions.

THE CODLING MOTH.

The larva of the codling moth (*Carpocapsa pomonella* L.), sometimes called the apple worm, is well known alike to growers and consumers of apples. It is the principal cause of wormy apples, and its control must be secured in profitable apple growing; otherwise from one-half to three-fourths or even a larger proportion of the crop will be wormy and unfit for market. No orchard insect, perhaps, is more successfully controlled than this one; and by careful spraying the fruit grower may expect to protect from its injuries from 90 to 95 per cent of the crop. Owing to the great extent of the apple-growing industry, there is, however, in the aggregate a large shrinkage in the quantity of marketable fruit, resulting from injuries by the codling moth. This shrinkage in the United States each year represents a loss of about $12,000,000, and some $3,000,000 or $4,000,000 are annually spent for sprays and labor in its control.

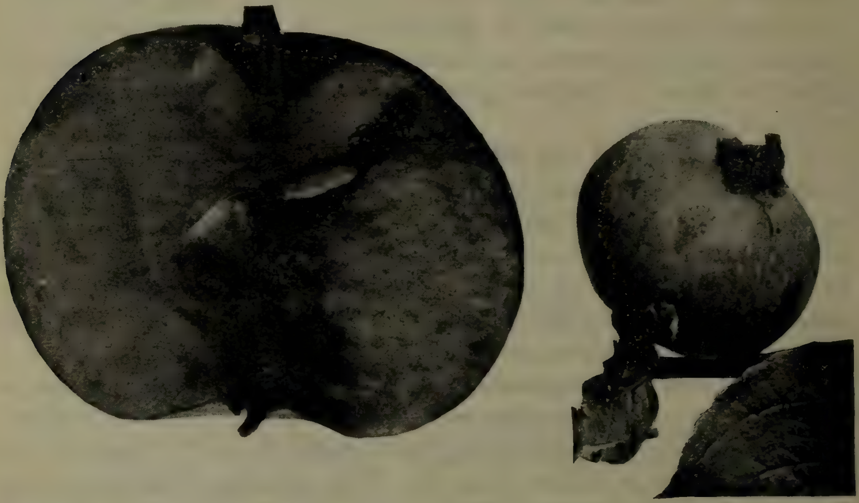


FIG. 1.—The codling moth larva (*Carpocapsa pomonella*) and its work: On the left, mature apple, showing full-grown larva and its work; on the right, frass from calyx end of young apple, infested with first-brood larvæ.

CHARACTER OF INJURY.

Wormy apples are shown in figure 1. The presence in apples of the apple worm early in the season is usually indicated by the occurrence at the calyx end of more or less frass. Fruit injured early in the season and while it is small mostly falls to the ground. Larvæ of the second and later broods occur when the fruit is more nearly grown, and it is the injuries of these broods that are observed in fruit on the market. The severity of attacks varies somewhat from season to season, and especially in different parts of the country, depending upon the number of broods of larvæ produced in the region in question.

NUMBER OF GENERATIONS.

The number of broods of larvæ of the codling moth for the country as a whole varies from practically one to three. Throughout the New England States and southward, at least to about the latitude of Washington, there is one full brood of larvæ each year and a partial second. In the northernmost part of the territory indicated, as in Maine and New York, the second brood of larvæ will be slight, varying in extent from season to season; while in the southern portion of this territory it is normally quite large, and during certain years there are practically two full broods. In the more southern States, as the Carolinas on the east and Arkansas on the west, there are probably three broods of larvæ each year. This has been determined to be true for Arkansas and Kansas. In New Mexico it is thought that the insect is three-brooded also.

It has been determined that there are two full broods of larvæ in States of the far West: Washington, Oregon, Idaho, Utah, and Colorado. The effect of such seasonal conditions as drought and temperature on the number of first-brood larvæ transforming for a given locality is quite marked. Thus, in Erie County, Pa., in 1907, with an abnormally late spring, only 3 per cent of the first-brood larvæ transformed, as compared with 68 per cent which transformed the following year and 23 per cent the next year.

DESCRIPTION AND LIFE HISTORY.

How the insect passes the winter.—Upon leaving the fruit in late summer or fall larvæ seek protected places upon the trees, such as holes, cracks, crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough silken cocoons, and here pass the winter in the larval condition. Large numbers of larvæ are carried to storage houses in apples in the fall, where later they spin cocoons in the boxes, bins, or barrels, or in cracks in the floor or sides of the house. In the orchard large numbers of larvæ are destroyed during the winter by birds, principally woodpeckers, but in storage houses a large proportion doubtless survive, the moths from which fly to the orchards in the spring and constitute an important source of infestation.

With the coming of spring the larvæ enter the pupal stage, and about the period of blooming of the apple, or somewhat later, the moths begin to appear, continuing to emerge for three or four weeks, while belated moths may not emerge until considerably later.

The moth.—The adult, or miller (fig. 2, *a*), is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch. The forewings above are of a brownish gray color, with numerous cross lines of gray. Near the tip of each wing is a conspicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow dark line. When at rest on the grayish bark of an apple tree, the moth in color so harmonizes with its surroundings that it is not readily distinguished, and the insect in this stage is perhaps little known to orchardists.

The egg.—The eggs are small, flat, somewhat oval in shape, and of about the size of a pinhead. When recently deposited they are of a pearl-white color, but become darker with the development of the embryo, which after a few days is easily distinguished as a reddish ring within the egg. Under a lens the surface is seen to be covered with a network of ridges, coarser toward the edge. The eggs of the first generation of moths are deposited mainly on the leaves and twigs, comparatively few being placed on the apple, possibly on account of the fine hairs with which this fruit is covered when small. More of the eggs of the second generation, however, are placed on the fruit, which by this time is much larger and presents a comparatively

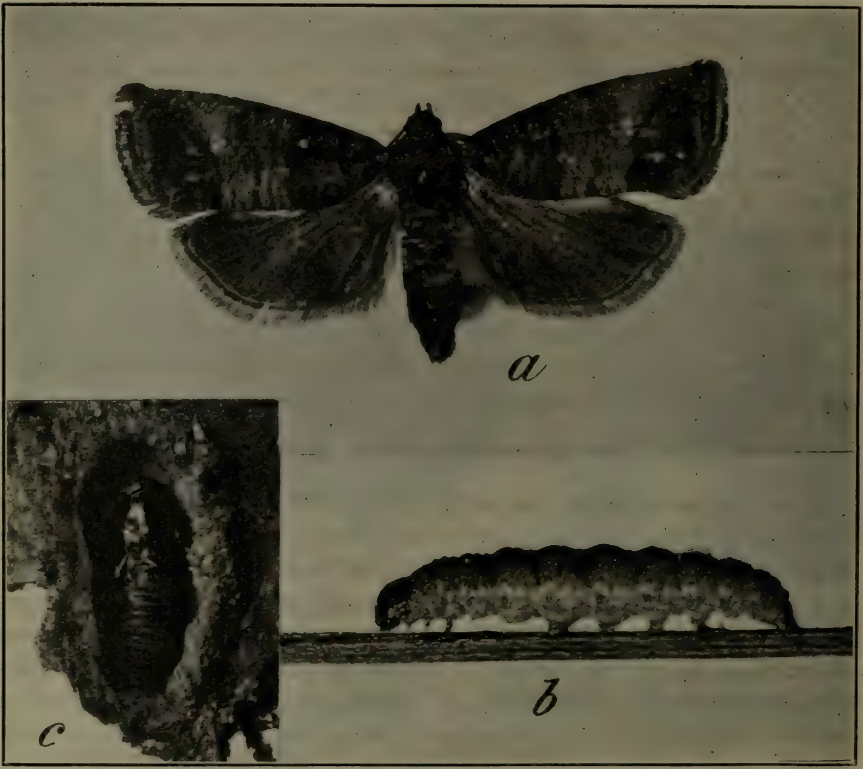


FIG. 2.—Stages of the codling moth: *a*, Moth; *b*, larva; *c*, pupa in its cocoon. Much enlarged.

smooth surface. The average time required for the egg to hatch is about 11 days, the time varying considerably, however, with the temperature.

The larva.—It is in the larval or "worm" stage that injury is done to the apple. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, but it soon begins to search for the fruit. If hatched from eggs placed here and there on the foliage, the larvæ chew more or less into the leaf or other portions of the plant in their wandering around and may thus be poisoned, if poison be present on the plants. If the eggs have been deposited on the fruit itself the larvæ are much more likely to gain entrance to the fruit. Larvæ entering the fruit by the calyx end feed within the calyx cavity for a few days before penetrating the fruit. Hence the advantage of thoroughly spraying trees shortly after the petals have fallen and while the calyx lobes are still spread, in order to place in each calyx cavity a small particle of poison to be eaten later by the larva as it seeks to enter the fruit.

After entering the apple the larva feeds and grows rapidly and in the course of about 20 days has become full grown. (See fig. 2, *b*.) At this time the "worms" are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below.

The pupa.—The full-grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon within which, in the course of a few days, it may change to pupa, or it may remain in the larval condition until the following spring, as already explained. The pupa (fig. 2, *c*) is about one-half inch long, at first yellowish or brownish, but later becoming quite dark brown, and shortly before emergence of the moth assuming a distinct bronze color. The pupal stage varies much in length, but on the average about 20 days elapse from the spinning of the cocoon until the emergence of the month. After emergence the moths, in the course of a few days, begin egg laying, the entire life cycle, from egg to egg, requiring, on the average, some 50 days.

TREATMENT.

The treatment for the codling moth is limited almost entirely to spraying the trees with arsenicals, such as Paris green or arsenate of lead; the latter is now principally used. In the East the poison is usually combined with a fungicide. In some sections banding of trees is also employed and under special conditions is a valuable adjunct to spraying. From two to five spray applications are given, according to the section of country.

First application.—Of all treatments, the first is much the most important; this is given as soon as the blossoms have fallen and has for its object the placing of poison in the calyx cup of each little apple. This treatment may be successfully given during the eight or ten days between the dropping of the petals and the closing of the calyx lobes. After the calyx lobes have drawn together it is difficult to force the poison into the calyx cup. (See fig. 3.) Very thorough work is necessary at this time, and carelessness in making the first application can not be counteracted by subsequent treatments. Good results, in fact, have been obtained where this application alone has been given; and in portions of the West, where it is unnecessary to spray for fungous diseases, a single treatment is held by some to be sufficient. While excellent results have been obtained in the East from this so-called "one-spray" method, yet the necessity of using fungicides in this territory renders the use of arsenicals in addition comparatively inexpensive.[1]

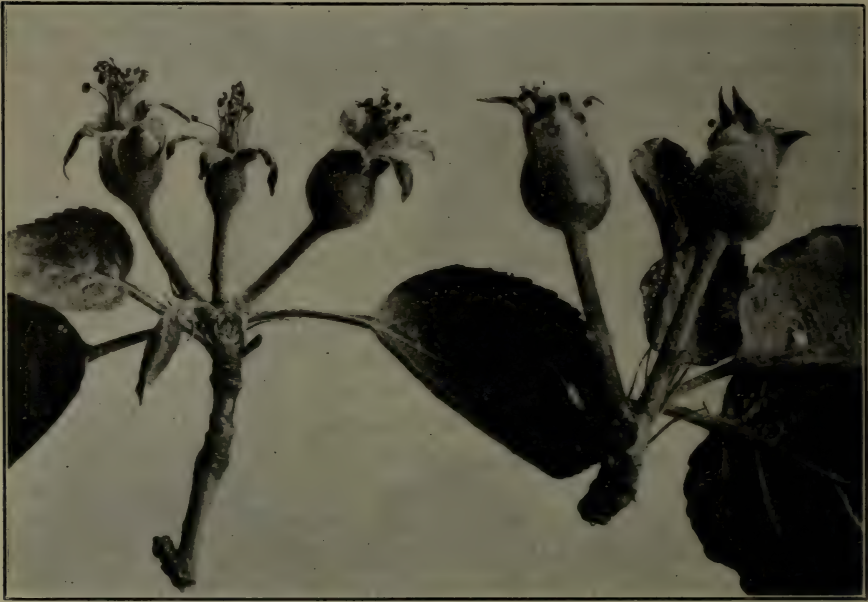


FIG. 3.—Apple clusters, showing, on the left, young fruit with calyx lobes spread, and in right condition for spraying; on the right, apples with calyx lobes closed, and too late for satisfactory spraying.

Second application.—The second application for the codling moth is given from three to four weeks after the blossoms have fallen and has for its purpose the destruction of the young larvæ as they are hatching from the eggs spread promiscuously over the foliage and fruit.

Third application.—Eight or nine weeks following the dropping of the petals the third treatment is given, at which time the second-brood larvæ are hatching in numbers.

---

[1] Those interested in the one-spray method should obtain copies of Bulletin 80, Part VII, and Bulletin 115, Part II, Bureau of Entomology.

These three treatments, if properly applied, should be sufficient to control the insect effectively in any region; but in a territory where bitter rot and apple blotch are prevalent, and where later fungicidal treatments are necessary, it will be advisable to add an arsenical for further insurance against the codling moth, as stated under the caption "Spraying schedule," pages 43–44.

THE PLUM CURCULIO.

The plum curculio (*Conotrachelus nenuphar* Herbst), over a great deal of its range, is easily second in importance as an apple pest to the codling moth. It occurs quite generally from Canada south to Florida and west to about the one-hundredth meridian. The insect is a small snout beetle, of the family Curculionidæ, and many of its near relatives, as the cotton-boll weevil, strawberry weevil, plum gouger, alfalfa weevil, etc., are very serious enemies of cultivated crops. The species attacks most cultivated pome and stone fruits, as apple, pear, peach, plum, cherry, etc., and it is especially troublesome to the peach.[1] In the present connection the insect is considered in reference to its injuries to apple.

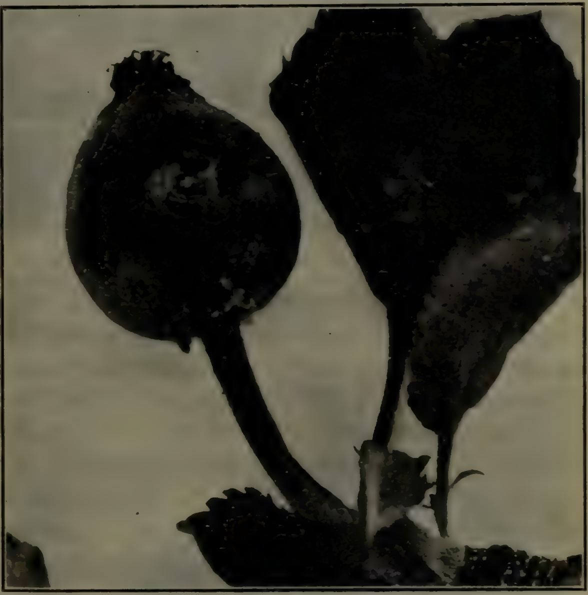


FIG. 4.—Egg scars of the plum curculio (*Conotrachelus nenuphar*) on young apples.

CHARACTER OF INJURY.

The overwintering beetles attack the young apples in the spring, shortly after these are well set. Both sexes puncture the fruit with their snout-like proboscis for feeding, and the females also in egg laying. Feeding and egg laying continue for several weeks or months in the case of the hardier individuals. Much of the fruit, punctured while small, falls to the ground, but after it has become about the size of a large marble or larger (see fig. 4), it may remain on the trees. The effect of the punctures when abundant, however, is to cause the fruit to become knotty and misshapen as it grows, the extent of the deformity varying with the severity of the injury and also with the variety. Rapidly growing summer or fall varieties of apples show the injury perhaps worst, while in the case of slower-growing winter apples the injury is more likely to be outgrown, the egg punctures showing in the fall as more or less nail-shaped scars, not affecting the quality of the fruit, though detracting from its appearance. (See fig. 5, showing deformed Duchess apples.)

---

[1] See Farmers' Bulletin 440, U. S. Department of Agriculture, Spraying Peaches for the Control of Brown-rot, Scab, and Curculio.

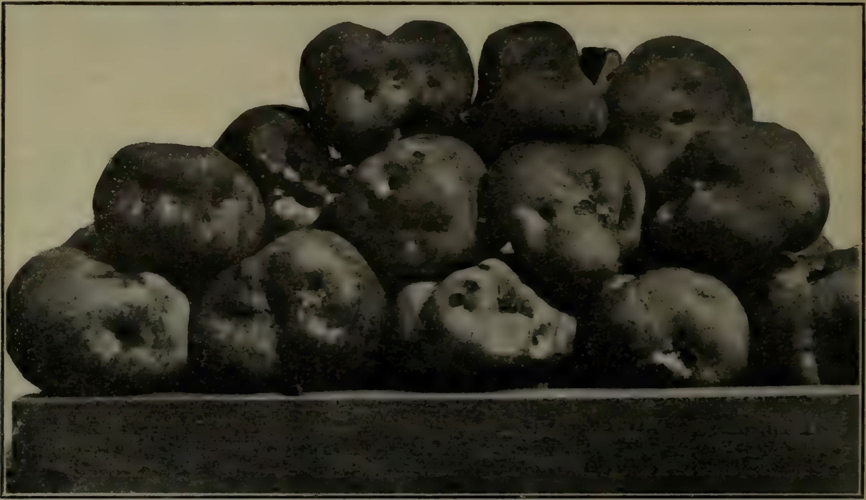


FIG. 5.—Duchess apples at picking time, showing deformed condition from egg and feeding punctures of the plum curculio.

When beetles of the new generation appear in late summer and fall they feed upon the fruits, producing injuries shown in figure 6. With the snout a hole is excavated in the apple, and the flesh is eaten out under the skin surrounding the puncture as far as this organ will reach. This " fall " feeding puncture is often very much in evidence in orchards where the insect is abundant, and the injury is at times considerable. Decay of the fruit often starts at the injured place,

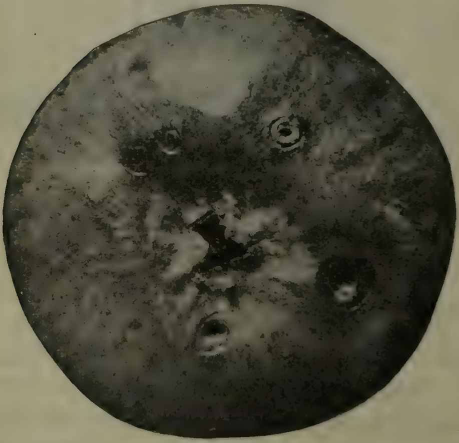


FIG. 6.—Fall feeding punctures of the plum curculio in ripe apple.

spreading from and enlarging the cavity, as shown in the figure, and soon rendering the fruit worthless, except for immediate use. Fruit thus punctured in the fall will not, as a rule, keep well in storage and should not, of course, be included in the best grades.

Although the curculio larva is able to develop on the trees in peaches, plums, and cherries, it does not appear to be able to do so in apples and pears. The larvæ, however, develop perfectly in apples which fall to the ground, and orchards are thus kept well stocked with the insect.

PERIOD OF OVIPOSITION AND NUMBER OF EGGS LAID.

The adult beetles are out and ovipositing on plums and other early fruit before apples, as a rule, are of sufficient size to be used. As soon as the apple is grown to the size of a small marble, however, it is attacked by the curculio for egg-laying purposes, and most of the eggs are deposited during the first six or eight weeks after egg laying begins. A large number of records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., has been obtained in different localities, as well as other data on the life and habits of the insect.

It has been found that the greatest number of eggs deposited by any one female was 557, and the minimum 1, with an average of 144.85 eggs per beetle for all the individuals under observation. While there is much variation in the number of eggs deposited within a given time in the several localities, there is a general agreement in that the great majority of the eggs are placed by the end of eight weeks; approximately one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks, and about 88 per cent of the total within eight weeks after oviposition began. The value of these data will appear when it is remembered that the injury to the apple results from the egg and feeding punctures, which it is desired to prevent. To accomplish this best, sprays must be applied with timeliness and be in effect over a considerable period.

TIME REQUIRED FOR TRANSFORMATION FROM EGG TO ADULT.

Many observations have been made in different localities, which show the time spent in the fruit by the curculio larva, and also the time spent in the ground, before and during pupation, until the emergence of the beetle. Thus the average time spent in the fruit (egg and larval stages combined), for the several localities investigated, proved to be 19.48 days, and the average time spent in the ground (as larva, pupa, and adult) was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete observations of the life cycle have also been made on a total of 597 individuals from many parts of the country, which give a final average per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The variation for different individuals will be considerable, and as actually determined in the case of individual records was from 37 to 58.45 days.

For practical purposes there is only one generation of the beetles each year. The adults, developing from fruit during the summer, spend the remainder of the time, until hibernation begins, feeding upon the foliage and fruit. With the approach of cold weather the beetles seek shelter, apparently wherever they may be, under trash in orchards, along fences, and in similar places. They are always abundant in woods adjacent to orchards.

CAN THE CURCULIO BE CONTROLLED BY SPRAYS?

During the past few years much experimental work has been done in the use of arsenical sprays in the control of the curculio on apple, notably by Prof. Stedman in Missouri and Prof. Crandall in Illinois. Prof. Crandall's investigations extended over two years. In regard to the value of the work he states as follows:

> To sum up the matter of spraying for the curculio from the standpoint of results obtained during the two seasons of 1903 and 1904, it seems possible, under favorable conditions and with a reasonable number of applications, to control curculios to the extent of from 20 to 40 per cent of the possible injury. There is benefit to be derived from spraying, but not that degree of benefit which would warrant commendation of spraying as the one great panacea of injury done by the curculio.

Many experiments by the Bureau of Entomology emphasize in general the soundness of the conclusions of Prof. Crandall. In the following table are given results of spraying for the curculio on apple as carried out by the Bureau of Entomology in different parts of the country.

TABLE I.—*Results of spraying apples for the plum curculio—various localities.*

Locality.	Treatment.	Number of sound apples.	Number of apples punctured.	Total number of apples.	Average percentage of sound apples.	Number of applications.
Anderson, Mo., 1908	Bordeaux mixture (4-4-50) plus ¼ pound Paris green.	1,710	1,867	3,577	47.81	7
Do	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	3,844	2,846	6,690	57.45	7
Do	Untreated	193	3,312	3,505	5.51	None.
Westfield, N. Y., 1908	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	10,506	921	11,427	91.07	4
Do	Untreated	300	761	1,061	25.44	None.
North East, Pa., 1906	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	1,354	359	1,713	79.04	2
Do	Untreated	270	791	1,061	25.44	None.
Siloam Springs, Ark., 1909.	Bordeaux mixture (4-4-50) plus 1 pound arsenate of lead. Trees drenched.	37,304	5,899	43,203	86.34	1
Do	Bordeaux mixture (3-3-50) plus 2 pounds arsenate of lead.	26,897	5,554	32,451	82.88	5
Do	Untreated	2,234	22,212	24,446	9.14	None.
Crozet, Va., 1909	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched.	15,406	5,432	20,838	73.93	1
Do	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead.	12,231	1,846	14,077	86.89	4
Do	Untreated	10,322	8,785	19,107	....	None.
Mount Jackson, Va., 1909.	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched.	11,335	8,240	19,575	57.90	1
Do	Bordeaux mixture (1-1-50) plus 2 pounds arsenate of lead.	6,651	9,642	16,293	40.82	[illegible]
Do	Untreated	6,984	18,657	25,641	27.23	None.
St. Joseph, Mo., 1909	Arsenate of lead, 2 pounds to 50 gallons of water. Trees drenched.	2,130	3,658	5,788	36.80	1
Do	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	2,480	2,470	4,950	50.10	4
Do	Untreated	182	4,307	4,489	4.05	None.

It will be noted that the results of spraying vary widely. It is apparent that account must be taken of other conditions, such as the relative abundance of the insects as compared with the amount of fruit present on the trees. With a small fruit crop and an abundance of curculios the most thorough spraying will not serve to bring through a satisfactory amount of sound fruit, as will be noted in the results of experiments at St. Joseph, Mo. With a large crop of fruit and an abundance of insects, results will likewise be disappointing; note the results at Mount Jackson, Va. If the curculios for any cause are scarce, and there is a large fruit crop, injury is, of course, much less important. In other words, the degree of success in spraying varies with the abundance of the insects. While spraying is undoubtedly a most important adjunct, and if persisted in from year to year may answer reasonably for its control, yet it is clear that where the insect is abundant other measures should also be employed. In all cases which have come under our observations the insects have always been found most abundant in orchards which are in sod or are poorly cared for and allowed to grow up more or less in weeds and trash. Orchards adjacent to woods will also usually suffer severely, especially along the border. As opposed to this condition is the notably less injury in orchards kept free from weeds and trash. In such cases the sprayings usually given for other orchard insects, as the codling moth, serve to keep the curculio well under control. In fact, it may be said as a general statement that this insect will never become seriously troublesome in apple orchards given the usual routine attention in cultivation, spraying, pruning, etc., now considered essential in successful fruit growing.

THE LESSER APPLE WORM.

The larva of the lesser apple worm (*Enarmonia prunivora* Walsh) and its work have been quite generally confused with those of the codling moth. The caterpillar when full grown is about one-half the size of the full-grown codling-moth larva, and is fusiform in shape and usually pink or flesh colored. A codling-moth larva of this size is rarely, if ever, pinkish in color, but dirty white, and marked with black dots. The injuries of the two species are in a way quite similar. The first-brood larvæ of the lesser apple worm enter the fruit mostly at the calyx end. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh, more or less around the calyx lobes and core within. The larvæ, boring directly through the skin at the base of the calyx lobes, or, more commonly, entering the calyx cavity, excavate mines or short burrows down into the flesh. Frequently also the larvæ burrow out in the calyx basin just under the skin, producing winding or blotch mines (see fig. 7). Such mines occur on the sides of the apple, especially where two fruits are in contact. Young fruit thus injured usually falls or ripens prematurely. Later in the season the calyx-end injury is about as described, though the surface injury is more common, the larvæ eating out the flesh under the skin in large, irregular, more or less linear patches, which are quite conspicuous. Larvæ of this species apparently do

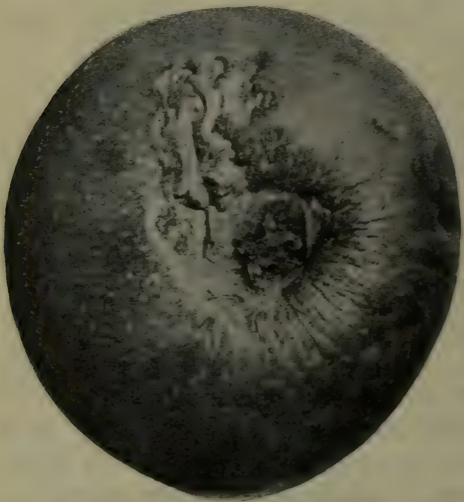


FIG. 7.—Injury by the lesser apple worm (*Enarmonia prunivora*) in calyx basin and end of a ripe apple.

not reach full development as early in the fall as those of the codling moth, and may find their way to barrels with the fruit, where they continue to feed, often doing considerable damage. Figure 8 illustrates apples thus injured, as found in barrels on the Washington market.

The lesser apple worm is probably a native insect, and it infests other fruits, wild and cultivated. It is recorded from apples, haws, plums, prunes, cherries, peaches, and species of Cratægus. It has also been reared from the black-knot of plum, and from galls on oak and elm.

Its life history and habits probably closely parallel those of the codling moth. It is known to be present quite generally in orchards from Canada south to Georgia and west to the Rocky Mountains. It has been found abundantly in apples in the Puget Sound district in Washington, and is known also from British Columbia.

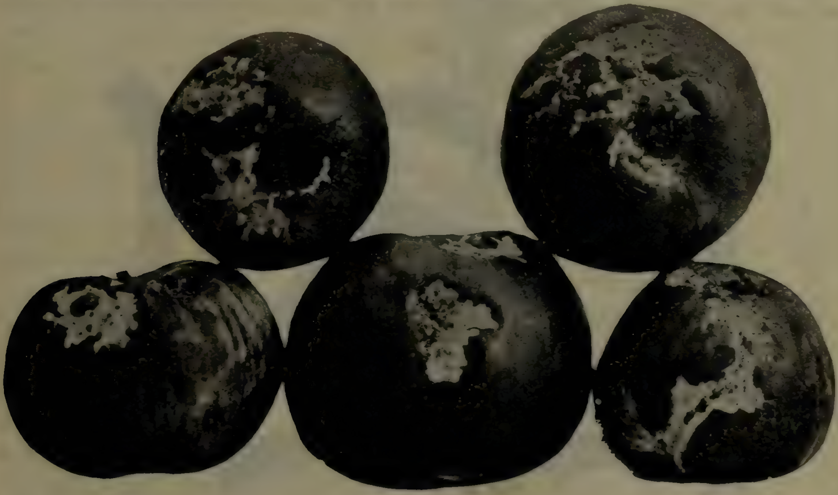


FIG. 8.—Injury by lesser apple worms to apples after barreling.

The schedule of treatments recommended for the codling moth will be effective in the control of this species.

CANKERWORMS.

Two species of cankerworms in the United States are often destructive pests in apple orchards, the larvæ making their appearance shortly after the leaves have put forth. The caterpillars (fig. 9) are rather small, slender, naked creatures with the habit of looping as they crawl, for which reason insects of this habit are commonly designated as "span worms" or "measuring worms." The fall cankerworm (*Alsophila pometaria* Harris) occurs more commonly in the northern United States, as from Rhode Island to Canada and westward to Lake Superior, and it is also common in California. The spring cankerworm (*Paleacrita vernata* Peck) is particularly abundant in the Mississippi Valley from Texas to Iowa, ranging eastward to Maine. It is common in the orchard section of northern Virginia, western Maryland, and West Virginia. The two species thus overlap in their distribution and both may be concerned in the defoliation of an orchard, especially in the northeastern part of the United States.

The fall cankerworm deposits its eggs in ringlike masses on the twigs during late fall or in warm periods during the winter. The spring cankerworm oviposits in early spring, before the buds start, in irregular masses under bark scales, along the trunk and limbs, or more or less promiscuously. The young larvæ have hatched and are attacking the foliage by the time the young leaves are well free from the bud scales. They often occur in such enormous numbers that the trees are quickly defoliated, leaving only the midribs of the leaves (see fig. 10), the orchard from a distance appearing as if swept by fire. After the larvæ mature they go to the ground and pupate just below the surface, and are easily destroyed by plowing and cultivations during the late spring and early midsummer. There is only one generation of the insects each year, the adults of the fall species coming out in late fall and winter, and those of the spring species in early spring, as stated. The adult females of both species are wingless and must crawl up the trunks of the trees to oviposit.

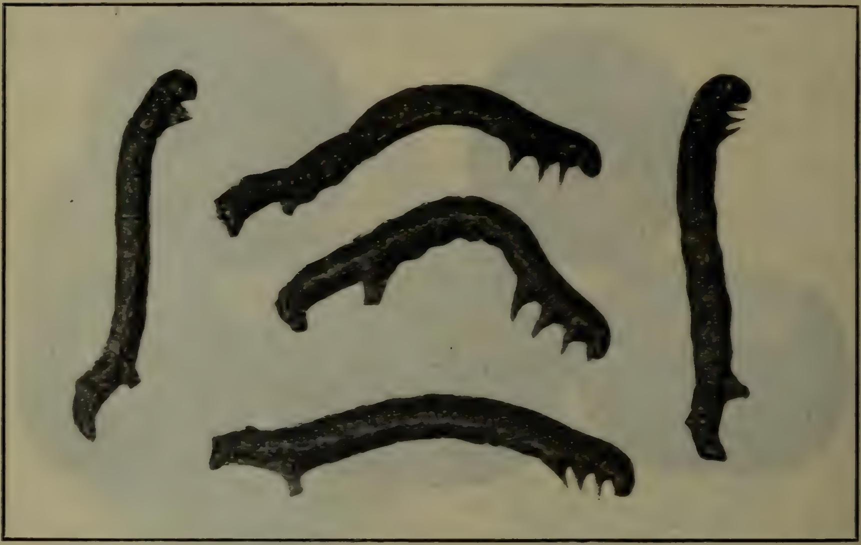


FIG. 9.—Spring cankerworms. Enlarged.

TREATMENT.

Three methods of control are applicable against cankerworms, and where the insects have been quite injurious the use of all three methods in conjunction may be adopted.

The wingless moths, and also the caterpillars, may be prevented to a large extent from reaching the foliage by the use of bands of sticky substances around the trunks of trees, some 12 to 18 inches from the ground. Some excellent preparations for this purpose are on the market, or homemade adhesives may be used. A simple plan is first to scrape off the rough bark from the trunk of the tree in a band 8 to 10 inches high, and surround the tree at this place with a strip of stiff paper, tying tightly, so that no moth or larva can work up the trunk beneath it. The paper band should then be coated with a sticky adhesive, which should be replenished as often as necessary to keep it in good working condition. This method is especially suited to large trees in lawns around the home, or elsewhere, where plowing and spraying are considered impracticable.

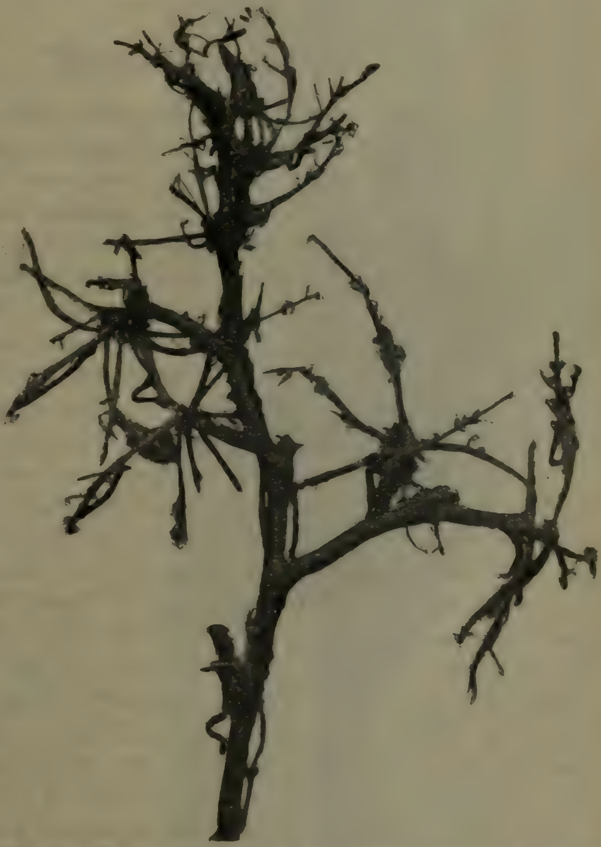


FIG. 10.—Work of the spring cankerworm (*Paleacrita vernata*) on apple.

The larvæ are readily poisoned with arsenicals, as arsenate of lead and Paris green, used at usual strengths. The first treatment for apple scab, while a little late for cankerworms, will in most cases answer fairly well, and where the insect is troublesome an arsenical should be added, as for the bud moth.

Plowing orchards during late spring and early summer, with a few subsequent cultivations, will destroy most of the pupæ in the soil. Care should be taken to stir the soil beneath the spread of the limbs of the trees, as in this soil most of the pupæ are located.

Except during very unusual conditions of abundance, orchards properly sprayed and cultivated will not be troubled by these insects. Cankerworms thrive in neglected old orchards in sod, and may appear for several seasons in succession, and by devouring the leaves destroy the fruiting capacity of the trees.

THE BUD MOTH.

The larva of the bud moth (*Tmetocera ocellana* Schiff.) winters in a little hibernaculum or cocoon of silk covered with bits of dirt and bark attached to the limbs and twigs of trees. Early in the spring, as the buds of the apple are opening, the little dark-brown caterpillars, scarcely one-fourth of an inch long, leave their winter quarters and attack the tender developing leaves, often boring into the bud before the scales have spread apart. When abundant the larvæ are thus able to do a large amount of injury. Severe damage may result to nursery stock or young trees following attack on the terminal buds of twigs or shoots. In some cases the twig itself is penetrated, the larva boring down into the pith some 2 or 3 inches.

After their appearance in spring the larvæ continue to feed, mostly at night, for some six or seven weeks, attacking principally the leaf and fruit buds. When full grown they pupate in a tubular fold of a leaf, well lined and securely fastened with silken threads; or two or three partly devoured leaves may be drawn together and within these the cocoon is made. In New York State, and probably in the New England States, in which region this pest is frequently complained of, pupation takes place on dates varying from about June 1 to June 25. Moths begin to emerge as early as June 5, and emergence continues somewhat later than July 10. Eggs are deposited for the most part singly on the lower surface of leaves and hatch in from 7 to 10 days. The newly hatched larvæ construct a tube along the midrib or larger vein of a leaf, from which they emerge to feed on the adjacent tissues, spinning as they go a web of silk for their protection. Feeding continues during July and August, and a few are thus engaged in September, when, deserting the foliage, hibernacula are constructed, as described, in which the half-grown larvæ remain until the following spring, attacking the buds as stated. The principal injury results from the attack to the unfolding buds and to the twigs in the spring, although in neglected orchards considerable injury to foliage may result from the feeding of the young larvæ during midsummer. In more northern latitudes the bud moth is single-brooded, though in the central and more southern States it is thought that there may be two broods of larvæ each year.

TREATMENT.

The control of the bud moth rarely requires treatments other than those given in the course of spraying adopted by progressive orchardists. The first treatment for the apple scab coincides fairly well with the time when these larvæ are actively feeding in the spring, and where their injury has been noted or is suspected an arsenical should be added to the fungicide used. The spray application after the falling of the blossoms, constituting the first treatment for the codling moth, is effective in further reducing the bud moth, and the two treatments should, under ordinary conditions, be sufficient to keep it well reduced.

THE APPLE-TREE TENT CATERPILLAR.

The conspicuous, unsightly nests or tents of the apple-tree tent caterpillar (*Malacosoma americana* Fab.) are not often seen in well-cared-for orchards, as this insect is kept well in check by the usual applications of arsenical sprays for the codling moth, curculio, etc. The nests, however, are often in evidence in neglected orchards and in trees along roadsides, and indicate a lack of interest on the part of the landowner in his orchard crops.

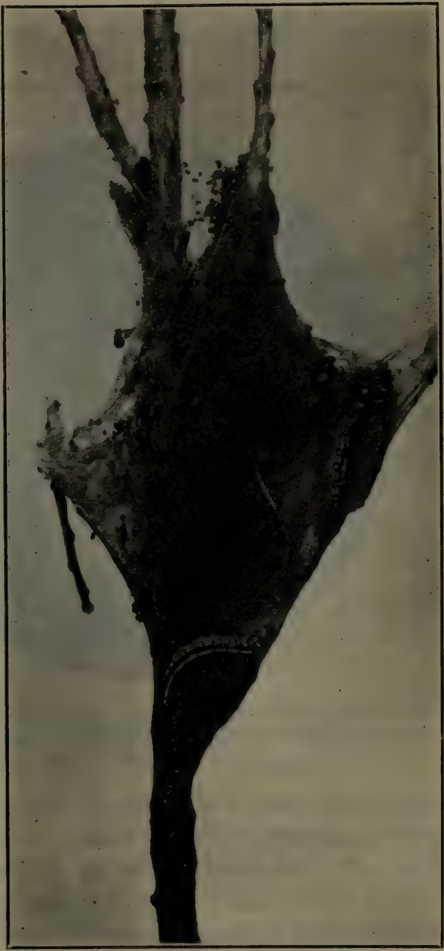


FIG. 11.—Nest and larvæ of the apple-tree tent caterpillar (*Malacosoma americana*).

The insect winters in the egg stage, the eggs being placed on twigs in a ringlike mass. The young larvæ appear as the foliage is pushing out in the spring and at once start their nest in the crotch of some limb or branch, in which they retreat for protection when not feeding. As the caterpillars grow the nest increases in size, until by the time the insects are full grown, it is a conspicuous, unsightly object. (See Fig. 11.)

TREATMENT.

As stated, orchards well sprayed for other fruit pests will rarely be seriously troubled by the tent caterpillar. Nevertheless the insect during certain seasons may become unusually abundant and special treatments may be necessary for its control. The destruction of the nests themselves and the contained caterpillars is comparatively easy. Where the nests are low down on the tree it will be practical to destroy them by hand, or, if the nests are out of reach, they may be destroyed by means of some form of torch on a pole, the torch being made of asbestos or other absorbent material saturated with an inflammable oil, such as kerosene or crude petroleum.

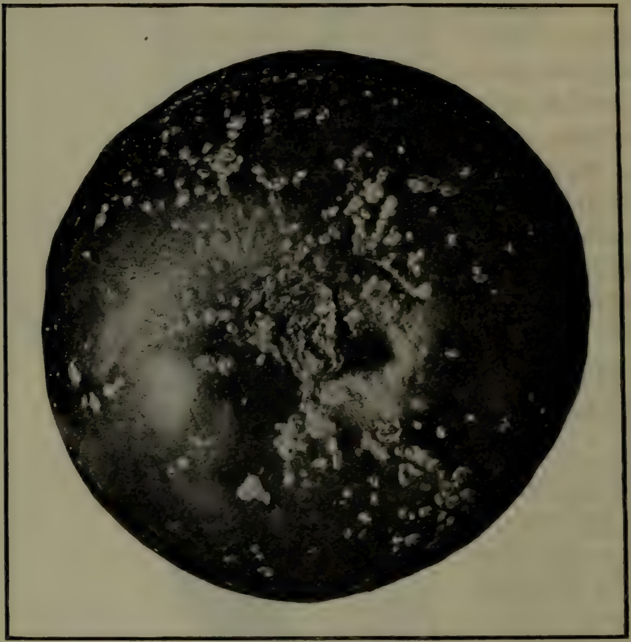


Fig. 12.—Baldwin apple badly infested with the San Jose scale (*Aspidiotus perniciosus*).

THE SAN JOSE SCALE.

The use of dilute lime-sulphur sprays as fungicides on trees in foliage appears to have a distinctly retarding effect on the development of the San Jose scale. While all orchards infested with this insect should be given the usual dormant tree treatment, for one reason or another considerable numbers of the scale may escape destruction, especially on the terminal twigs, which are more difficult to coat thoroughly with the wash. The scales which thus escape are usually so few in number that no serious damage results during the season to the twigs and branches, but the young "lice" have a tendency to crawl out and settle on the fruit, thereby greatly disfiguring it. (See Fig. 12.) The presence of these scales is very objectionable on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign governments, and is discriminated against by buyers generally. The following data (Table II) on the effect of sulphur sprays in lessening scale infestation of the fruit were obtained by Mr. E. W. Scott, of the Bureau of Entomology, in the course of some experimental work during 1911, at Fennville, Mich.:

TABLE II.—*Results of lime-sulphur sprays in preventing marking of fruit by the San Jose scale.*

Plat No.	Treatments.[1]	Variety.	Number of apples infested.	Number of apples not infested.	Total number of apples.	Percentage of uninfested apples.
1	Commercial lime sulphur, 1½ to 50; sprayed May 12, 25, June 14, July 25.	Rhode Island Greening.	137	1,606	1,743	92.13
2	.....do	Baldwin	80	778	858	90.67
3	Home boiled lime sulphur, May 12,25, June 14, July 25.	Greening	79	3,939	4,018	98.03
4	.....do	Baldwin	37	1,813	1,850	98.00
5	Commercial lime sulphur, 1½ to 50; May 12, 25, June 14, July 25.	.....do	13	298	311	95.81
6	Bordeaux mixture (3–4–50), May 12, 25, June 14, July 25.	Greening	843	1,055	1,898	55.58
7	.....do	Baldwin	525	500	1,025	48.78
8	Unsprayed	Greening	796	805	1,601	50.28
9	.....do	Baldwin	809	190	999	19.01

[1] All treatments had 2 pounds of arsenate of lead to each 50 gallons of spray, except in case of plat 5, which had the poison in the application of May 12 only.

The influence of the sulphur sprays in checking the settling of the young scales on the fruit is here very marked and furnishes an added reason for the use of sulphur sprays as fungicides.

APPLE SCAB.

ECONOMIC IMPORTANCE.

Apple scab is a fungous disease of the fruit and foliage of the apple and ranks as the most destructive disease to which this fruit is subject. In unsprayed orchards it often causes the loss of 50 to 75 per cent of the crop, and not infrequently the entire crop of certain varieties is rendered unfit for market by the deformed, cracked, and unsightly condition produced by the fungus. Affected fruit is usually small, unsightly, often cracked, and does not keep well. However, since the practice of spraying has become general among apple growers this condition has been largely relieved.

DISTRIBUTION.

Apple scab is common practically wherever the apple is grown—in America, Europe, Australia, New Zealand, and elsewhere. However, it is essentially, a cool-climate disease, and in the United States it is most destructive in New England, the Middle Atlantic States, the Great Lakes region, the Mississippi and Ohio Valleys, and portions of the Pacific Northwest. In the Southern States it is not a serious pest, except on the higher elevations, and then only on very susceptible varieties.

CHARACTER OF THE INJURY.

The fungus causing apple scab attacks the fruit, foliage, and to a much less extent the twig. The greatest damage is done to the fruit, on which it produces the scabby spots familiar to most apple growers. These spots are circular, though somewhat irregular, in outline, dark gray or olivaceous in color, becoming blackish with age, and they range in size from mere specks to spots one-fourth inch or sometimes one-half inch in diameter. (See fig. 13.) The fungus ruptures the epidermis of the apple, forming a gray, jagged ring at the border of the healthy tissues. Two or more spots may coalesce, forming a large scabby area, in some cases covering one side of the apple. The disease prevents the normal development of the fruit, the affected side becoming dwarfed, pitted, and otherwise deformed. It also causes the development of cracks, which may extend half way around the apple and almost to the core. A large percentage of the affected fruit drops to the ground before maturing.

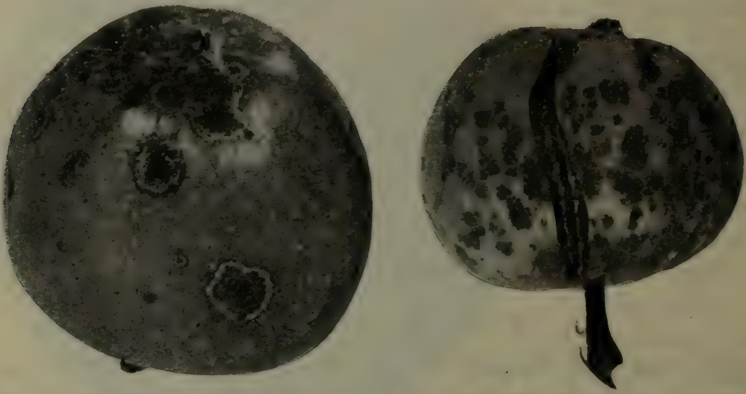


FIG. 13.—Apples affected with the scab fungus, the one on the left showing characteristic spots and the one on the right smaller spots with crack.

In a cool, wet spring the blossom buds and young fruits in blossom may be attacked and destroyed. Occasionally, though rarely, the entire crop of an important fruit section may be destroyed in this manner.

The disease occurs on both sides of the leaves, forming smoke-brown or olivaceous patches which become swollen and blisterlike. (See fig. 14.) The affected leaves often curl somewhat and may drop prematurely. The fungus is said to occur also on the twigs, forming blackish-olive patches, but this is apparently not common in the United States.

THE FUNGUS CAUSING THE DISEASE.

Apple scab is caused by a fungus known as *Venturia pomi* (Fr.) Wint., which lives over winter in the fallen apple leaves. In the spring, when the weather becomes warm enough to start apple trees into growth, the fungus becomes active, producing large numbers of spores, which are discharged into the air and carried to the young leaves, blossom buds, and later to the young fruit. If there is sufficient moisture present these spores germinate, producing infections that develop into the characteristic scab spots. Summer spores are soon produced on these spots, and through them the fungus may readily spread to other fruits and leaves.

The period of greatest infection is from the time the first apple leaves appear until about four weeks after blooming. The fungus thrives best in cool, moist weather, such as is likely to occur during this period. Hot weather is very unfavorable to it, and infections rarely take place after summer sets in. However, in the New England States a second infection period sometimes occurs during September, and from these late infections small scab spots may develop after the fruit is picked and stored.

TREATMENT.

Scab was one of the first apple diseases to receive attention by investigators, and its successful treatment was worked out as early as 1891. Until quite recently spraying with Bordeaux mixture constituted the remedy for it, but owing to the injurious effect on both fruit and foliage produced by this otherwise excellent fungicide, especially during wet seasons, dilute lime-sulphur solution is rapidly coming into use as a substitute for it. Lime-sulphur solution has about the same fungicidal value as Bordeaux mixture in the treatment of apple scab and produces decidedly less injury to fruit and foliage.

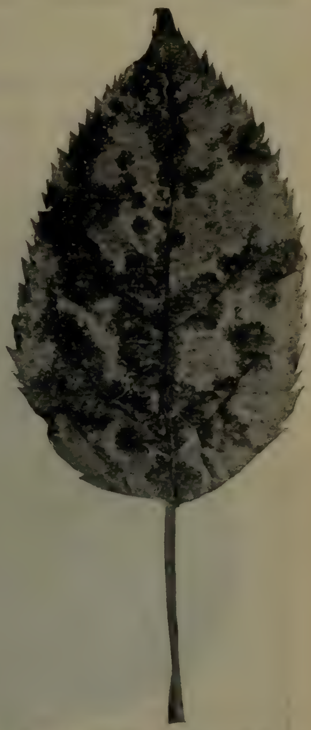


FIG. 14.—The scab fungus on apple leaf.

Lime-sulphur solution may be purchased from several manufacturers or it may be prepared at home. (See pp. 38–40.) Taking a solution that registers 32° on the Baumé hydrometer as a standard, the strength to use in spraying for scab is 1¼ or 1½ gallons to each 50 gallons of water. On varieties seriously attacked by scab and in localities where the disease thrives the greater strength should be used, but in order to reduce the danger of injury to a minimum the weaker spray should be used where only slight outbreaks of scab are expected. Arsenate of lead at the rate of 2 pounds to each 50 gallons of solution should be added to control the codling moth, curculio, and other insects.

Spray the trees (1) when the cluster buds open, just before blooming; (2) as soon as the petals fall; and (3) two or three weeks later. Varieties only slightly affected by scab, especially in the South, do not require the first application of this series, the two sprayings after the petals fall being sufficient to prevent the disease. On the other hand, in New England an extra application about the middle of August may be required to prevent late scab infections on some very susceptible varieties.

BITTER ROT.

ECONOMIC IMPORTANCE.

In sections where it is prevalent bitter rot is the most dreaded of all the common apple diseases. After the fruit has been safely nursed through the attacks of scab and the codling moth and is about ready to be harvested an outbreak of bitter rot may destroy the entire crop of some varieties without much warning. It is rather spasmodic in its appearance, depending largely on weather conditions. Hot weather with plenty of moisture is essential to the rapid development of the disease, and it therefore does not occur to any serious extent in the more northern parts of the apple belt nor in the drier sections of the West. It is well distributed throughout the Southern States where apples are grown, extending into southern Illinois, and has in the past destroyed several million dollars worth of apples during a single season. However, in recent years, since its treatment has been better understood and more thoroughly put into practice, the annual losses have not been so great.

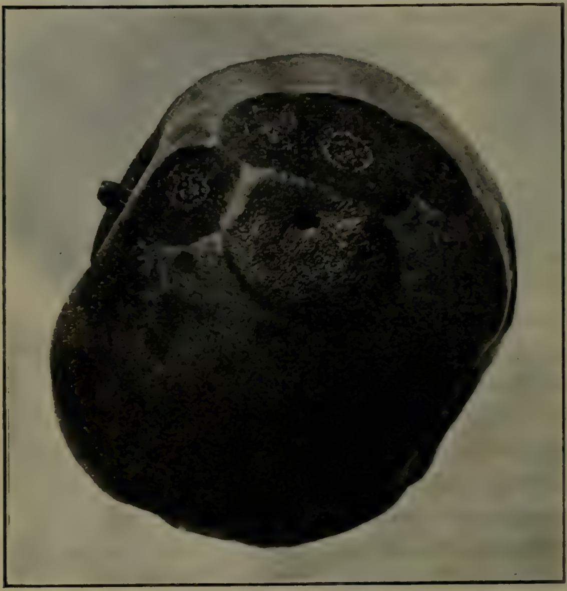


FIG. 15.—Apple affected with bitter rot.

CHARACTER OF THE INJURY.

The bitter-rot disease appears on the fruit as a circular brown spot with concentric rings of fruiting pustules. (See fig. 15.) The young spots are very small and often show purplish or reddish margins, but under favorable conditions they rapidly enlarge, involving the entire apple in decay. The disease extends inward toward the core at about the same rate as the spread on the surface, forming a cone-shaped area which can be easily crushed out with the fingers. Owing to the shrinking of the invaded tissues, the spots become somewhat sunken, and this distinguishes it from black rot and brown rot. Several spots, or, in severe cases, several hundred spots, may occur on the same apple, although one spot is sufficient to destroy the whole fruit.

CAUSE OF THE DISEASE.

Bitter rot is caused by the fungus *Glomerella rufomaculans* (Berk.) Spauld. and Shrenk, which invades the tissues of the apple, producing the familiar spots described above. It passes the winter in cankers on the limbs and in mummied fruits. Under favorable weather conditions spores from these sources and perhaps from unknown sources infect the fruit, starting an outbreak of bitter rot. When the germ tube, resulting from the germination of a spore, finds its way through the skin of the apple, it immediately begins to branch and grow rapidly, obtaining its food supply from the tissues and causing these to die and turn brown. After a time clusters or tufts of fruiting branches are formed and these burst through the skin in rings, producing pink masses of spores which serve to spread the disease to other apples. Millions of spores are produced from a single spot, so that under favorable conditions the entire crop of an orchard may become diseased from one center of infection.

In addition to the summer spores or conidia, there are produced on the mummied fruits and in limb cankers winter spores or ascospores, which constitute the perfect stage of the fungus. It is not definitely known that these ascospores play any important part in the life history of the fungus.

THE LIMITING FACTORS.

Barring preventive measures, the two limiting factors determining bitter-rot outbreaks are weather conditions and varietal resistance. Heat and moisture are essential to the vigorous growth of the fungus, and of these two heat is the more important. While hot, showery, or muggy weather is ideal for the development of the fungus, serious outbreaks of the disease may occur during comparatively dry weather, provided the temperature is high and the dews are heavy at night.

Infections may take place at any time during July, August, and September, but rarely earlier or later. High summer temperatures are required for the rapid growth of the fungus, and these are the months in which such temperatures usually occur. Infections may begin to take place during the latter part of June if the weather conditions are right, but since the fungus does not thrive on young, green fruits, no serious outbreak need be feared until July. Owing to climatic influence the bitter-rot disease is confined mainly to the southern tier of apple-growing States.

The second limiting factor, namely, varietal resistance, varies in different sections of the country. For example, the Yellow Newtown in Virginia is very susceptible to the disease, and under favorable conditions the entire crop may be destroyed, while the Ben Davis in the same orchard will become only slightly, or not at all, affected. On the other hand, the Ben Davis, in portions of the Middle West—southern Illinois, southern Missouri, and northwestern Arkansas—is one of the most susceptible varieties. This would indicate that there are two strains of the fungus, the Ben Davis being susceptible to the one occurring in the West and resistant to the one occurring in Virginia.

The most susceptible varieties grown in bitter-rot sections are Yellow Newtown, Willow, Huntsman, Smokehouse, Stark, Jonathan, Ben Davis, and many other less prominent varieties.

TREATMENT.

Although it has been abundantly demonstrated that bitter rot can be readily controlled, even under the most severe conditions, many apple growers look upon it as the most treacherous of all the diseases with which they have to contend. The chief reason for this is the irregularity with which the disease appears. One year an outbreak may occur in July, while the next year the disease may not appear until September. Varieties partly resistant to the disease may go through several seasons without becoming affected, but when there comes a season unusually favorable to the fungus, much of the fruit of these varieties may be destroyed by the disease. This erratic habit of the disease keeps the apple grower in doubt as to when to expect it and when to spray. He does not care to give his orchard three or four bitter-rot sprayings when there is no bitter rot to fight, and he is loath to begin the treatment in June if the disease does not occur until September, yet the only safe plan in bitter-rot districts is to expect the disease every year and to keep the fruit protected from the latter part of June until the end of September.

Bordeaux mixture is still the best fungicide to use for bitter rot, the lime-sulphur solution having proved only partially effective against this disease. Fortunately Bordeaux mixture has very little or no injurious effect on the apple after the young fruits have attained an age of 6 or 8 weeks, and may therefore be used for bitter rot with comparative safety.

As to strength, the mixture should be used as weak as is consistent with good results in order to avoid as much as possible leaving a stain on the ripe fruit. A mixture composed of 3 pounds of bluestone and 4 pounds of lime to each 50 gallons of water, if properly applied, is sufficient for ordinary bitter-rot treatment; but the very susceptible varieties in districts where the disease is common should be sprayed with a stronger mixture, composed of 4 pounds of bluestone and 4 pounds of lime to 50 gallons of water.

In order to protect the fruit throughout the possible bitter-rot infection period the trees should be sprayed four times at intervals of two to three weeks, beginning seven to eight weeks after the petals have been shed. In the bitter-rot belt the dates of the application would be about as follows, though varying somewhat with the season: (1) June 25–30, (2) July 10–15, (3) July 25–31, and (4) August 10–15. Such a course of treatment, properly carried out, will secure protection against outbreaks of bitter rot under the most adverse conditions. By observing the weather conditions and watching for the first infections the first application may be delayed a few days and the intervals lengthened so that three sprayings can be made to do the work. With very susceptible varieties this is risky, but with varieties only moderately susceptible three sprayings are sufficient.

The removal of cankered limbs and the destruction of bitter-rot mummies doubtless help to control the disease, and should be practiced, but these precautions can not take the place of spraying.

For the control of the second brood of the codling moth arsenate of lead at the rate of 2 pounds to each 50 gallons of Bordeaux mixture should be used in the second and third bitter-rot sprayings.

APPLE BLOTCH.

Apple blotch may be considered the scab disease of the South, its effect on the fruit being very similar to that of apple scab. It is well distributed over the southern half of the apple belt, beginning approximately where apple scab leaves off, although there is considerable overlapping of the two diseases at some points. At present the disease is most destructive in Kansas, Oklahoma, Arkansas, Missouri, Kentucky, and southern Illinois. The destruction of half the crop of certain varieties is not an infrequent occurrence in some of these badly affected districts. The disease occurs on the fruit, twigs, and leaves, but the principal damage is done to the fruit.

CHARACTER OF THE INJURY.

On the fruit.—Apple blotch appears on the fruit as a hard brown spot with a roughened surface and a somewhat jagged margin. The blotch or spot is at first very small and light brown in color, but it gradually enlarges, finally attaining a size of one-fourth or sometimes one-half inch in diameter. (See fig. 16.) The advancing margin usually has a fringed appearance, and the surface is dotted with minute, black, raised dots known as pycnidia.

The spots may become so numerous as practically to cover one side of the apple, causing it to ripen and drop prematurely. They are usually accompanied by a cracking of the fruit, thus opening the way for other fungi and insects as well. Some of these cracks are very small, while others are half an inch or more in length. The appearance of affected fruit is so marred as to render it practically unfit for market.

On the twigs.—The fungus causing apple blotch attacks the twigs, fruit spurs, and "water sprouts," producing small brown cankers with purplish margins. These cankers are usually only about one-fourth by one-half inch in size, but may become considerably larger and often girdle the affected twig. With age the bark over the diseased area becomes cracked and scales up, giving the canker a rough appearance. These cankers as a rule do no serious damage to the tree, but the fungus passes the winter in them and they thus become a dangerous source of infection for the new fruit crop.

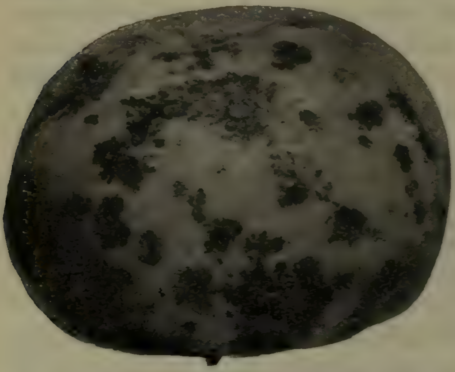


FIG. 16.—Maiden Blush apple affected with apple blotch.

On the leaves.—The leaves also become affected and here the disease manifests itself in the form of very small light-brown or yellowish spots. These spots are angular in outline and attain a size of only about one-sixteenth of an inch in diameter. The spots are usually very numerous on leaves of trees affected with the twig cankers, but they are so small that the injury produced is not often serious.

CAUSE OF THE DISEASE.

Apple blotch is caused by the fungus *Phyllosticta solitaria* E. & E. The fungus lives over winter in the twig cankers, where it is perennial, and in the spring produces spores which ooze out in great numbers from little black raised points or pycnidia. These spores are carried to the fruit by rains, wind, and perhaps insects. Upon germination in the presence of moisture they throw out one or two fungous threads, which penetrate the skin, become much branched, and grow slowly in a radial manner, finally producing the brown blotches.

On the young spots the fungus growing underneath produces small black receptacles in which spores are borne. These spores, when discharged, may infect other fruits, leaves, and twigs.

INFECTION PERIOD.

The fungus in the twig cankers becomes active about the time the apple trees bloom, and about four weeks later fresh spores are produced, ready to infect the fruit and leaves. If the weather conditions are favorable, infections, therefore, begin to take place from four to five weeks after the petals fall. Infections may continue to take place for several weeks, but as a rule the chief damage to the fruit crop results from the infections occurring within six weeks after the petals fall. Spraying for its control should, therefore, be done in time to protect the fruit from these early infections. The fungus is a slow grower and the spots may not show up until two or three weeks have elapsed after infections have taken place, so that to begin spraying when the first spots appear would be much too late to prevent the disease.

TREATMENT.

Unfortunately the lime-sulphur sprays have not proved entirely satisfactory for the control of apple blotch. In orchards where the disease is not very serious lime-sulphur solution may be used with good results, but for the present at least the chief reliance for the prevention of the disease should be placed on Bordeaux mixture. Lime-sulphur solution should be used with the first codling-moth spray as soon as the petals fall, thus avoiding a part of the danger of spray russet, and Bordeaux mixture should be used in the subsequent applications. The spraying schedule for bad cases of apple blotch should be about as follows: (1) Lime-sulphur solution as soon as the petals fall; (2) Bordeaux mixture three weeks later; (3) Bordeaux mixture six weeks after the petals fall; and (4) Bordeaux miture nine weeks after the petals fall. In a dry season the third treatment may be omitted, and in mild cases lime-sulphur solution may be used in all the applications. For the control of the codling moth and curculio, arsenate of lead should be added to the first, second, and fourth treatments.

CEDAR RUST.

Cedar rust, also known as orange rust, is a disease affecting both fruit and foliage of the apple, quince, and other pomaceous plants. It is common in practicaly all the apple-growing districts east of the Rocky Mountains, causing considerable damage to certain varieties of apples. In some sections the disease is troublesome nearly every year, but as a rule destructive outbreaks occur at rather wide intervals, depending upon weather and other conditions. Since the fungus causing the disease passes the winter on cedar trees and infection can take place only with spores from that source, the disease is confined to localities where the red cedar occurs.

CHARACTER OF THE INJURY.

On the leaves the cedar rust disease manifests itself at first as minute, pale-yellow spots, which slowly enlarge, finally attaining one-eighth to one-fourth inch in diameter and becoming orange-colored, with small black dots in the center. (See fig. 17.) Some time later, on the under side of the leaf beneath each spot the tissues become swollen, forming a blister or cushion on which cup-shaped spore receptacles are produced. These cluster cups are small tubular projections with fringed margins.

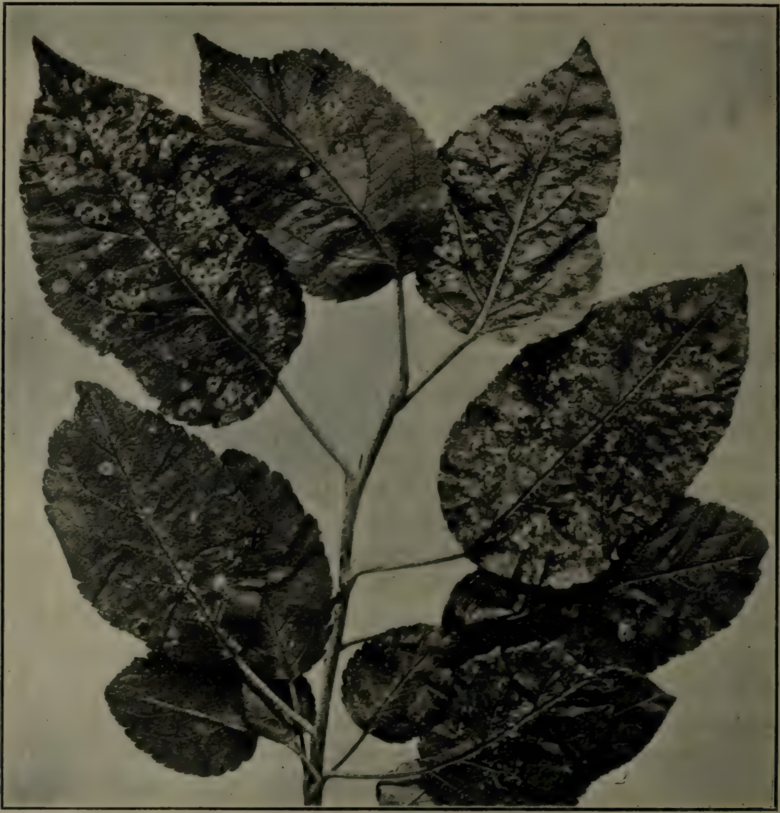


FIG. 17.—Foliage of York Imperial apple affected with cedar rust.

When only a small percentage of leaves is affected, as is frequently the case, no noticeable damage results, but susceptible varieties adjacent to cedar trees may become so badly affected that the trees appear yellowish, even from a distance. In such cases the function of the leaves is so interfered with that the fruit, the buds for the following year, and the tree itself are not properly nourished. This results in small, immature, poorly colored fruit, as well as weak buds and a weakened condition of the tree. Badly affected leaves usually drop prematurely.

Cedar rust appears on the fruit of the apple as bright yellow spots about one-half inch in diameter or sometimes larger. Both the black dots and the cluster cups occur on the spots, the latter usually forming one or more rings near the margin. (See fig. 18.) The spots may occur at any point on the fruit, but they are most frequently found near the blossom end. In severe cases the affected fruit may become deformed or atrophied, but as a rule there is no disfiguration other than the presence of the yellow spot. The market value of affected fruit is naturally reduced, much of it being discarded as culls. The disease on the fruit is not so important as that on the foliage, the greater damage being caused by the latter.

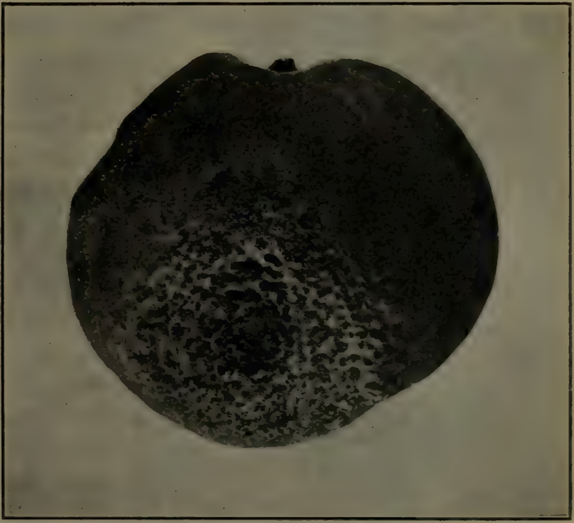


FIG. 18.—Cedar rust disease on the apple.

LIFE HISTORY OF THE CEDAR-RUST FUNGUS.

There are several different species of rust fungi which pass a part of their existence on the red cedar and are obliged to spend the remainder upon the apple or some other pomaceous plant. Perhaps the most common of these is the one known as *Gymnosporangium juniperi-virginianæ* Schw. The spores produced in cluster cups which occur on the diseased leaves and fruit of the apple are carried by the wind to the red cedar trees, infecting the twigs of the latter and thus producing the well-known "cedar apples." (See fig. 19.) These are reddish-brown, globular swellings ranging in size from one-fourth to 1 inch or more in diameter when mature. The fungus thus established on the cedar passes the winter and develops during the following summer, enlarging the gall, and finally during the second spring throws out long, yellowish, gelatinous projections in which spores are borne. These spores, while still in the gelatinous mass, germinate, producing a short fungus growth which bears a crop of smaller secondary spores. When the yellowish mass dries these secondary spores are carried like dust particles on the wind and when lodged on the fruit or foliage of the apple germinate, giving rise to a fungous thread, which enters the tissues and finally produces the characteristic yellow or orange-colored spots. Later the cluster cups are formed on the underside of the leaf and on the fruit spots. In these cups are produced another kind of spore, which is carried back to the cedar trees, as previously indicated. This takes place during July, August, and September. The spores produced on the apple can not reinfect this plant, but must find their way to the cedar or perish. Spores for the infection of the apple must come from the cedar.

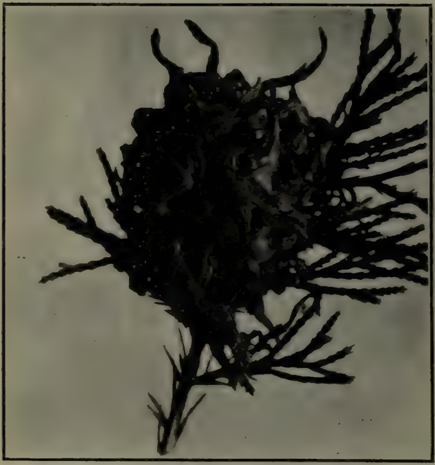


FIG. 19.—Cedar rust disease on the cedar. (Cedar apple.)

INFECTION PERIOD.

Plenty of moisture is required, both for the production of spores on the cedar apples and for the germination of these spores on the leaves and fruit of the apple. It naturally follows, then, that a serious outbreak of the disease is likely to occur during a wet spring, while if dry weather prevails very few, if any, infections can take place. Beginning about the time apple trees are in bloom, infections may take place over a period of three to six weeks, depending upon weather conditions. In warm, wet weather during this period the cedar apples throw out the yellow gelatinous masses in which the spores are produced. These may dry out and swell up again several times with alternate dry and wet weather, more spores being liberated each time. Such weather conditions prolong the infection period and result in a serious outbreak of the disease on the apple.

TREATMENT.

Since the fungus causing the disease comes from the cedar trees and since the apple can not become infected from any other source, the natural and most effective remedy is to destroy all red cedars in orchard districts. The cedars in fields or woods adjacent to the orchards are the most dangerous, but since the spores are like particles of dust they may be carried on the wind for several miles. However, upon being carried so far they would be scattered over a wide area and the chances for serious infection of any one orchard would usually be slight, especially since moisture is necessary for the germination of the spores after they reach the apple. Orchards with no cedar trees within a mile may be considered fairly safe from infections. In cleaning up the cedars, the underbrush, fence rows, and hedges should be carefully searched for young cedars. Little cedar plants only a foot high often have cedar apples, and these are usually overlooked by the orchardist.

Spraying has not proved entirely satisfactory in the control of this disease, although much can be accomplished by this method. The usual treatment for scab and leaf-spot, namely, spraying (1) just before the blossoms open, (2) as soon as the petals fall, and (3) three weeks later, will largely prevent this disease during some seasons. In showery weather, however, an extra application should be made about 10 days after the petals fall. The sulphur sprays appear to be somewhat more satisfactory for the control of this disease than the copper sprays.

APPLE LEAF-SPOT.

With the possible exception of cedar rust, leaf-spot, also known as frog-eye, is the most important fungous disease affecting the foliage of apple. It occurs in all sections east of the Rocky Mountains where the apple is grown and in unsprayed orchards causes considerable damage by defoliating the trees.

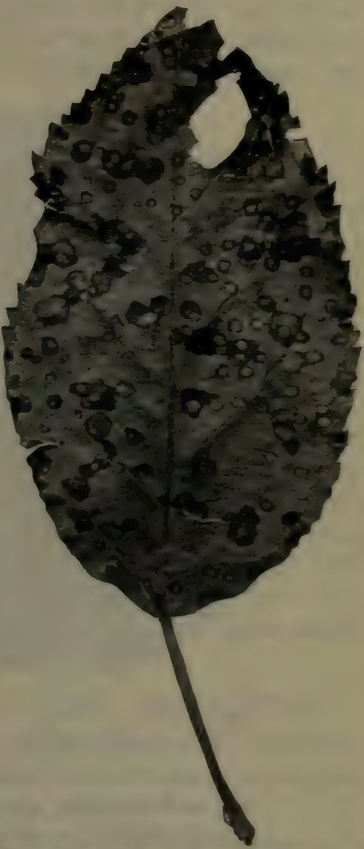


FIG. 20.—Apple leaf-spot on leaf of Ben Davis apple.

The spots are circular or somewhat irregular in outline, and reddish-brown in color, becoming grayish with age. (See fig. 20.) At first they appear as minute purple specks, which rapidly enlarge until a diameter of from one-eighth to one-half inch is reached. The mature spots are usually circular, but after midsummer may become irregular or lobed in outline, due apparently to a secondary extension of the disease from two or more points on the margin of the original spot.

The leaf-spot disease begins to appear early in the spring soon after the first leaves unfold and infections may continue to take place until midsummer or somewhat later. A large number of spots may occur on a single leaf and in bad cases the trees may become defoliated six weeks or two months before the ripening time of the fruit. As a result of this premature defoliation the fruit either drops off or remains small and is of poor quality, the fruit buds are so weakened as to decrease the chances for a crop the following year, and the trees are materially weakened.

CAUSE OF THE DISEASE.

The black-rot fungus known as *Sphæropsis malorum* Peck is the cause of apple leaf-spot, or at least it is the most common cause. Other fungi frequently occur on the diseased areas, but they are apparently secondary, and it has never been definitely proved that any of them are capable of producing the leaf-spot described above.

The black-rot fungus is perhaps the most common fungus that occurs in pome fruit orchards. In addition to the apple leaf-spot, it is the cause of the black-rot of apple, pear, and quince, and produces cankers on the trunks and branches of these fruit trees. It also grows and fruits on twigs killed by pear-blight and other parasites. Spores are produced in great abundance on these dead twigs and it is from this source that the leaves most commonly become affected. The fungus fruits on the leaves hanging on the trees only sparingly, but after the diseased leaves drop to the ground spores are produced abundantly.

TREATMENT.

Apple leaf-spot is easily controlled by spraying with lime-sulphur solution. The treatment for apple scab, as already outlined, will effectually prevent this disease, no special treatment being necessary where the usual orchard spraying is practiced. During the process of pruning affected twigs should be cut off and burned, so as to eliminate this important source of infection.

SOOTY FUNGUS AND FLYSPECK.

Toward the end of the growing season apples may become affected with large sooty blotches composed of dark olive-brown matted fungus threads. When numerous these blotches give the skin of the apple a clouded effect and many fruit growers have learned to call the disease "cloud." The fungus is superficial, growing on the surface of the apple, and it does not produce any noticeable diseased condition of the tissues. However, the sooty or clouded appearance which characterizes the disease injures the market value of the fruit, rendering it practically unsalable. (See fig. 21.)

With the sooty spots are usually associate groups of small, circular, dark-colored flecks. This is a fungous trouble known under the common name of flyspeck. (See fig. 21.) It also mars the appearance of the fruit, but not to such an extent as the sooty spots. According to Duggar[1] sooty blotch and flyspeck are stages of the same fungus (*Leptothyrium pomi* [Mont. & Fr.] Sacc.), although for years they have been considered as two distinct fungi.

The sooty fungus and flyspeck are common throughout the Eastern States and in unsprayed orchards often cause considerable damage. The fungus thrives best in moist, shaded places and is especially troublesome when cloudy, showery weather prevails during late summer or fall.

TREATMENT.

The sooty fungus and flyspeck are more easily prevented than any other disease affecting the apple, as would naturally be expected from their superficial habit of growth. When treatment for bitter-rot is practiced these troubles need no further consideration. Even the fungicide in the last spraying for apple scab will hold over long enough largely to prevent them unless the conditions during late summer are specially favorable, in which case an application of Bordeaux mixture or lime-sulphur solution should be made in July. In low, damp situations an application during the first week in July and another during the first week in August, using a weak Bordeaux mixture, will often be found desirable.

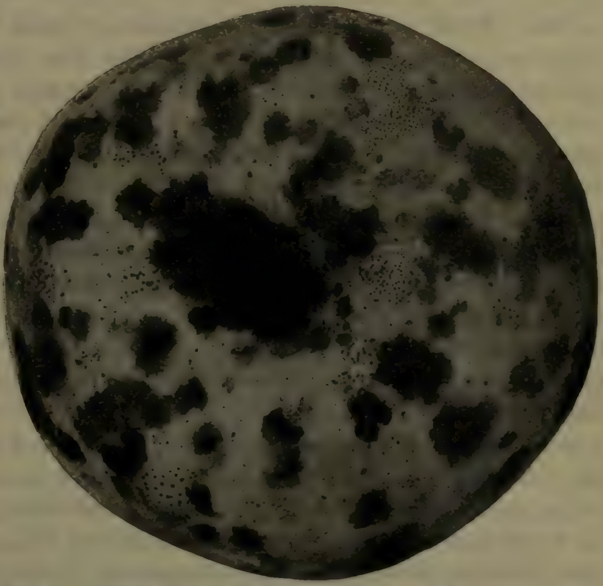


FIG. 21.—Sooty fungus and flyspeck on the Huntsman apple.

PREPARATION AND USE OF SPRAYS.

The several troubles herein considered are, for the most part, satisfactorily controlled by a thorough use of sprays. During the past few years there have been important improvements in the field of orchard spraying as regards the materials used and also in the character of machinery employed. At the present time orchardists, by careful attention to details, are able to obtain a much higher benefit from spraying operations than formerly, and while results vary, depending upon weather and other conditions, yet the successful orchardist now expects to harvest, as sound fruit, from 90 to 95 per cent of his crop. Below are given the spray materials recommended in the present bulletin, with directions for their preparation.

---

[1] Fungous Diseases of Plants, pp. 367–369.

LIME-SULPHUR SOLUTION.

Uses.—Fruit growers have now become quite familiar with lime-sulphur sprays as a remedy for the San Jose scale, peach leaf-curl, and blister mite, and other troubles requiring dormant tree treatment. The lime-sulphur wash, as used on dormant trees, has gone through a good deal of evolution since the California formula was first employed in the East. Whereas a few years ago it was the practice to make the wash at home for immediate use, utilizing for this purpose in many cases very large cooking outfits, the tendency at the present time is toward the employment of the commercial lime-sulphur solution, a concentrate which is kept indefinitely and used as needed, or a similar homemade solution, both of which are prepared on a distinctly different formula from the wash as formerly used.

A distinct advance was made in the control of fungous diseases when it was found that these commercial and homemade lime-sulphur concentrates, properly diluted, could be used with satisfactory results as fungicides on trees in foliage, replacing Bordeaux mixtures, the use of which is attended with danger of russeting the fruit and injuring the foliage, depending upon weather conditions.

Home-boiled lime-sulphur solution.—Concentrated lime-sulphur solution, to be diluted and used for the summer spraying of orchards, may be prepared by boiling together for about 50 minutes, 100 pounds of sulphur, 50 pounds of lime, and water to make 50 gallons of concentrated solution. Any finely powdered sulphur of 98 to 99 per cent purity may be used. The commercial ground sulphur is the cheapest form and is as good as the flowers or flour for that purpose. The best grade of fresh stone lime is required for the best results, although a good grade of hydrated lime may be used, provided proper allowance be made for the high percentage of moisture it contains.

The boiling may be done in barrels or vats with steam or in kettles over a fire. An ordinary 75 to 100 gallon food cooker composed of a kettle with jacket and fire box is perhaps the most convenient and economical outfit for small and medium sized orchards.

Place about one-fourth of the required amount of water in the kettle, bring it to the boiling point, then put in the lime and immediately add the sulphur. Stir vigorously until the lime is slaked, then add sufficient water to finish with 50 gallons of the concentrated solution and boil for 50 minutes. The total time of actual boiling should not exceed 1 hour, and, as a rule, a boiling period of only 50 minutes gives better results. After the sulphur has gone into the solution, combining with the lime to form sulphids, further boiling brings about a chemical change which finally results in throwing some of the sulphur out of the solution to form a sediment. The sulphur should first be passed through a sieve to break up any lumps that it may contain, and there is perhaps some advantage in working it into a thick paste with water before adding it, or the sulphur may be placed in the kettle first and worked into a paste before adding the lime. In order to finish with 50 gallons of solution the kettle should be filled to about 58 gallons, on account of evaporation. If the water evaporates to below 50 gallons more water should be added to make up the loss. A measuring stick with a 50-gallon mark, and other marks as desired, will be found useful in determining the amount of liquid in the kettle. When steam is used the process is about the same as above described. Owing to the condensation of the steam a somewhat smaller amount of water is required. When the boiling is finished the solution should be poured through a strainer of about 20 meshes to the inch, so as to remove the coarse particles of sediment. It may be used immediately or stored in barrels or other containers and kept indefinitely, provided the air is excluded. In practice the fruit growers, as a rule, have not been able to prepare the lime-sulphur solution without obtaining a large amount of sediment and this has tended to make the commercial product more popular. This sediment is due largely to impurities in the lime and improper mixture and boiling. Straining will take out the coarser particles, and the remainder will not prove to be seriously objectionable.

After the sediment has been settled, the clear liquid should test 25° to 28° on the Baumé hydrometer. It takes about 2 gallons of the homemade preparation to equal in strength 1½ gallons of the commercial product, and these amounts, respectively, are the amounts required for each 50 gallons of spray. For the summer spraying of apple trees, lime-sulphur solution, whether home-made or commercial, should be so diluted as to contain 3½ to 4 pounds of sulphur in each 50 gallons of spray. Prepared according to the above directions, 1 gallon of the homemade product contains approximately 2 pounds of sulphur in solution, and therefore 2 gallons would give the requisite amount of sulphur for each 50 gallons of spray. For spraying trees during the dormant season it should be used much stronger, 12 to 15 pounds of sulphur to each 50 gallons of diluted spray being required. For dormant tree spraying about 7 gallons of the home-made solution in each 50 gallons of spray would therefore give the proper strength.

Commercial lime-sulphur solution.—For some years manufacturers of insecticides and fungicides have had on the market concentrated solutions of lime-sulphur, originally designed as treatment for the San Jose scale, which obviated the necessity of orchardists preparing the wash at home. These solutions have now come to have a much wider range of usefulness, forming a satisfactory substitute, in most cases, for Bordeaux mixture as a fungicide. These concentrated solutions, for the most part, are well made and are fairly uniform in strength, registering from 30° to 34° on the Baumé scale. Many orchardists prefer to use them rather than to prepare the spray at home. In the case of small orchards their use is doubtless advisable, but where the orchard interest is considerable the fruit grower might well afford to prepare the concentrate at home.

In the use of the commercial lime-sulphur solution, as in the home-made solution, the orchardist should know rather exactly the proper dilution to make which will insure the control of the troubles in view, and on the other hand not prove injurious to the foliage and fruit. Dilutions are based on the strength of the concentrate as shown by its specific gravity. Thus commercial lime-sulphur showing a density of 32° on the Baumé scale should not be used stronger than 1½ gallons for each 50 gallons of spray. According to the writers' observations a variation of 2° above or below the density indicated is immaterial as regards danger of foliage injury, so that the recommendations hold for practically all of the commercial concentrates on the market. Where the fungous troubles to be treated are not very serious, it is recommended that only 1¼ gallons of the concentrate should be used to each 50 gallons of spray in order to eliminate, in so far as possible, the danger of injury to fruit and foliage.

BORDEAUX MIXTURE.

Bordeaux mixture is composed of copper sulphate (bluestone) and quicklime, with a certain quantity of water. The amounts of copper sulphate and of lime to be used with a given quantity of water vary somewhat, according to the kind of plants or trees to be sprayed and the disease to be treated. When used on the apple the following formula is quite satisfactory for general orchard work:

Copper sulphate (bluestone)	pounds	3
Quicklime	do	4
Water to make	gallons	50

In bad cases of bitter rot or apple blotch it is often advisable to use 4 pounds of bluestone and 6 pounds of lime to 50 gallons of water instead of the above formula.

Directions for making.—To make a single barrel of Bordeaux mixture, dissolve the bluestone in 25 gallons of water and in a separate vessel slake the lime and dilute it to 25 gallons. Then pour the two solutions simultaneously through a strainer into the spray tank.

If large quantities are to be used, stock solutions of the bluestone and lime should always be prepared, thus saving the time necessary to dissolve the materials. A stock solution of the copper sulphate may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or box with perforations in the bottom and sides) containing 50 pounds of copper sulphate in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the sulphate will have entirely dissolved, and the sack or box should be removed and enough water added to fill the barrel. After slight stirring the solution is ready for use. The stock lime may be prepared by slaking 50 pounds in a barrel or other vessel, and finally adding water to make 50 gallons. In slaking the lime sufficient water should be used to prevent burning, but not enough to " drown " it, and the mass should be continually stirred with a shovel or spading fork until a thin paste is formed.

In making Bordeaux mixture take the necessary quantities of the stock copper sulphate and the stock lime solutions to give the formula in the total amount of water to be used, and place each in separate elevated dilution tanks, which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and, according to the above formula, 20 pounds of copper sulphate (20 gallons of the stock solution) and 20 pounds of lime (20 gallons of stock solution) would be required. To each dilution tank add water (one-half the total amount of spray) and after stirring allow the diluted ingredients to run through separate hose or troughs attached to faucets near the bottom of the tank into the strainer on the spray tank, where the two solutions come together, producing the Bordeaux mixture. Only the quantity which can be used during the day should be mixed, as the Bordeaux mixture deteriorates on standing.

In case the dilution tanks are not elevated to admit of filling the spray tank by gravity, the diluted solutions must be dipped and poured into the latter by hand, a bucketful of each simultaneously. This method is advisable in small operations, where a few barrels at most are needed.

It is important that Bordeaux mixture should be thoroughly strained in order to keep out any coarse particles that would clog the spray nozzles, and it is a good practice to strain the stock solution of lime while pouring it into the dilution tank. The best material for a strainer is brass wire netting of about 20 meshes to the inch.

ARSENATE OF LEAD AND OTHER ARSENICALS.

Arsenate of lead is the principal arsenical used in orchard spraying. It comes on the market in a puttylike paste and to a more limited extent in the form of a powder. Its present large use is due to certain advantages it has over other arsenicals, in that it contains very little water-soluble arsenic, and is therefore much less likely to injure the foliage. It also adheres better than other arsenicals, such as Paris green and arsenite of lime. All arsenicals used in spraying fruit trees may be used in Bordeaux mixture. However, not all of these can be used in lime-sulphur solutions without danger of foliage injury. Arsenate of lead when added to lime-sulphur solution undergoes considerable chemical alterations, as shown by the prompt change in color of the mixture. Chemical analyses show that a small percentage of the arsenate of lead is broken down, and lead sulphid and arsenate of lime formed. Abundant experience, however, has shown that this alteration of the chemical nature of the arsenical and of the lime-sulphur wash does not injuriously affect their efficiency as fungicides and insecticides, nor materially add to the danger of foliage or fruit injury. Arsenate of lead is used in Bordeaux mixture or lime-sulphur at the rate of 2 pounds to each 50 gallons of the spray. As there are numerous brands of arsenate of lead upon the market the grower should be careful to purchase from reliable firms. When the paste form of arsenate of lead is used it must be worked free in water before it is added to the spray. Powdered arsenate of lead is used at about one-half the strength of the paste form.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed and thinned with water. In all cases the arsenate of lead should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

Arsenite of lime is recommended by Stewart[1] as an arsenical for use in lime-sulphur solution, but when so employed the Kedzie formula should be somewhat modified as follows:

White arsenic	pounds	2
Sal soda crystals[2]	do	2
Water	gallons	1½

Boil the above ingredients together in an iron vessel until entirely dissolved, which will require about 15 minutes. This solution is then used to slake 3 or 4 pounds of best stone lime. If the slaking is thoroughly done, the arsenic will be well combined with the lime and the product will retain its strength indefinitely. After slaking, add enough water to bring the total up to 2 gallons. This is a stock solution, which after having been labeled to indicate its poisonous nature, may be stored for use as needed. The stock solution, after thorough stirring, is used at the rate of 2 pints for each 50 gallons of lime-sulphur spray and contains the equivalent in arsenic of one-half pound of Paris green.

This preparation may be used equally well in Bordeaux mixture.

Paris green may be used in Bordeaux mixture at the rate of 5 or 6 ounces for each 50 gallons of spray. This poison, however, should not be used in lime-sulphur spray.

SCHEDULE OF SPRAY APPLICATIONS.

In connection with the several insects and diseases previously referred to, information has been given as to the treatment to be employed in their control. It rarely happens, however, that the orchardist has to consider only one or two of these troubles, there being present as a rule several important insect or fungus pests which must be considered. Fortunately for the orchardist, many of his most serious troubles permit of control by a few well-timed applications of a combined insecticide and fungicide, such as lime-sulphur wash and arsenate of lead. It is, therefore, possible to indicate a schedule of applications which has been found satisfactory to protect fruit and foliage from injury. An outline of this kind, however, must be very elastic to apply to the varied conditions obtaining in the various orchard sections of different parts of the country, as, for instance, in the New England States and in the Ozark region of Arkansas. The orchardist, therefore, must know what his troubles are in order to save himself the expense of unnecessary treatments, on the one hand, and of serious loss, on the other, on account of failure to spray where such work is desirable. The following schedule of applications is recommended, and if carefully followed out it should insure protection against practically all of the troubles affecting the fruit and foliage of the apple:

---

[1] Bul. 99, Pennsylvania Agricultural Experiment Station.

[2] If the anhydrous or water-free sal soda is used, one-half the quantity will be sufficient.

First application.—Use lime-sulphur solution at the rate of 1½ gallons to 50 gallons of water plus 2 pounds of arsenate of lead paste or 1 pound of powdered arsenate of lead just before the blossoms open. This is for apple scab, the plum curculio, cankerworms, the bud moth, case-bearers, and the tent caterpillar.

Second application.—Use same spray as in first application, as soon as the blossoms have fallen. This is for the above-mentioned troubles as well as for the codling moth, leaf-spot, and cedar rust. It is the most important application for both apple scab and the codling moth. In spraying for the codling moth at this time the aim is to place in the calyx end of each little apple a quantity of the poison and, to accomplish this, painstaking work will be necessary. Failure to do thorough spraying at this time can not be remedied by subsequent treatments.

Third application.—Use the same spray as indicated above three to four weeks after the blossoms fall. This is the second treatment for the codling moth, cedar rust, and leaf-spot, and gives further protection against apple scab.

Fourth application.—Use Bordeaux mixture (3–4–50 formula) and an arsenical eight to nine weeks after the petals fall (about June 25 to 30). This is the first application for bitter rot, the arsenical being added for the second brood of the codling moth. It is also essential for the sooty blotch and flyspeck, especially in damp situations.

The applications given above, if carefully followed out, are, as a rule, sufficient to bring the fruit crop through to maturity in good condition, except where bitter rot occurs, for which further treatment will be necessary as indicated below.

Fifth application.—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter rot, and since it is very little extra expense to add an arsenical this may be profitably done as a further protection against late-appearing larvæ of the codling moth.

Sixth application.—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter rot sections, a treatment to be made two weeks later may be found necessary.

Apple-blotch treatment.—The second, third, and fourth applications of the above schedule will control mild cases of apple blotch, but in bad cases an extra treatment, using Bordeaux mixture, applied six weeks after the petals have fallen (two or three weeks after the second application), will be found necessary for the best results.

Many orchards located in the Middle Atlantic States and southward do not require the first application of the above schedule. Only bad-scabbing varieties, like Winesap, need spraying at this time, unless cankerworms or the bud moth should prove serious enough to necessitate a special spraying. The York Imperial and Ben Davis varieties, which constitute a large proportion of the orchards throughout this region, rarely need spraying before the trees bloom.

EQUIPMENT FOR SPRAYING.

With other conditions favorable, the orchardist will not be able to secure satisfactory results in spraying unless he uses an efficient spraying outfit. While there has been a notable improvement in the character of spraying machinery used by orchardists during the last few years, there are yet many outfits in use which greatly handicap the work. At the present time there are on the market a large series of makes of spray pumps, many of which are quite efficient for the purpose for which they are designed, and the orchardist should not be satisfied with any but the best.

The barrel type of spray pump is serviceable in small to medium sized orchards and when properly fitted with hose of sufficient length, a good agitator, and good nozzle, very effective work may be done. The pump, according to design, may be fitted to the end or side of the ordinary 50-gallon kerosene or similar barrel and may be mounted on a sled or wheels, or preferably placed in a cart or wagon. One man is required to pump and one or two men to handle the nozzles, depending on whether one or two leads of hose are used. A good barrel pump should supply two leads of hose, each with double nozzles. Tank outfits are mostly used in the larger orchards, but are very desirable for the small orchardist as well. These outfits consist of rectangular or half-round tanks, flat on top, holding from 100 to 300 gallons of the spray mixture, fitted to the wagon in place of the wagon bed. Some growers use a 100 to 200 gallon tank placed on one end of the wagon. The barrel type of pump may be used on these tanks, but for this purpose it is better to use the larger tank pumps with suction hose. The hole in the top of the tank should be covered with a close-fitting lid to keep out leaves, twigs, and other trash, which would clog the pump and nozzles.

However, in large commercial orchards power sprayers are mostly used, such as gasoline, compressed air, etc. With such outfits a much higher pressure may be maintained than is possible with hand pumps, giving a fine spray, which may be driven to all parts of the tree. Sufficient power will be furnished to supply several leads of hose and the spraying may be done rapidly, which is very important, especially in regions where suitable days for spraying are not frequent. The usual defect in spraying outfits is that the hose is not of sufficient length. Each lead of hose should be from 25 to 35 feet long, and provided with an 8-foot to 12-foot bamboo extension rod. This length of hose will permit the complete spraying of a tree before leaving it, insuring more thorough work than if only one side is sprayed at a time, and the amount of driving necessary will be reduced by one-half.

The nozzle, of which there are many kinds on the market, is a very essential part of the spraying outfit. Whereas a few years ago the nozzles available were far from satisfactory for orchard spraying, there are now to be obtained good nozzles for the purpose. For general spraying the Vermorel or eddy chamber type of nozzle, of which there are various modifications, is best. These nozzles give a spray of different degrees of fineness, depending upon the size of the aperture of the cap used. In the spray application given immediately after the falling of the petals, especially to lodge poison in the calyx cups for the control of the codling moth, a cap with a large opening is used by many orchardists, and some fruit growers, especially in portions of the West, use at this time a still coarser spray, as that from the "Bordeaux" or similar nozzles. Information on this point as obtained by the Department of Agriculture under humid conditions indicates that there is no advantage in using so coarse a spray, such as is produced by Bordeaux nozzles, especially since a much larger amount of spray is required and greater injury may result.

In spraying high trees some form of elevated platform should be constructed on the wagon, on which one of the men holding the nozzles may stand to spray the higher parts of the tree, the other men spraying from the ground as high as may be reached and overlapping the work of the men on the tower.

In many commercial orchards more time is consumed in driving to and from the water supply than in actually applying the spray. This can be remedied by the use of a supply tank which will hold 200 to 300 gallons. One hand should be able to prepare the mixtures and deliver them to the sprayers in the orchard, thus keeping the outfit constantly in operation. The mixture may be quickly transferred from the supply tank by means of a rotary pump attached to the engines or by other tank-filling devices.

APPLYING THE SPRAY.

Sprays are preventive and not curative, and must therefore be applied before the injury becomes apparent. After a fungus has gained entrance to the foliage or fruit it can not be reached and the diseased parts made sound again; but the infection may be prevented by coating the parts with a fungicide, such as lime-sulphur solution, which prevents the germination of the spores. Similarly, the codling moth may not be poisoned after it has burrowed into the fruit, but if the poison has been put into the calyx cavities before the calyx lobes have closed, and has been sprayed on the foliage and fruit before the latter is entered by the larvæ, the destruction of the latter in large numbers is insured. Successful spraying, therefore, must be based on a knowledge of the diseases and insects to be controlled. With all of the affections here considered the work should be done in advance of their expected appearance in the orchard.

There are two principal reasons why spraying in the hands of some is unsatisfactory, namely, failure to make the applications at the proper time and failure thoroughly to coat the trees and fruit with the mixture. In order to overcome the former difficulty the orchardist must be informed as to the nature of the malady or insect to be treated, and the latter may be overcome by maintaining proper equipment and by giving the necessary attention to thoroughness in spraying.

In the operation of spraying the liquid should be broken into a very fine mist. The nozzles should be so manipulated that every part of the foliage and fruit shall be uniformly covered with fine dots of the spray. It is not necessary that the foliage and fruit should be actually coated with the spray, but every portion should be thickly peppered with it. The higher and inner portions of the tree are commonly insufficiently sprayed, and while the liquid may actually be dripping from the lower branches the upper parts of the tree may show little of the spray.

The desired mistlike spray can ordinarily be secured only with high pressure at the pump. This pressure should be not less than 100 pounds, though this is not ordinarily obtained except with gasoline or other power outfits, which should supply a pressure of 125 to 150 pounds. When hand pumps are used the pressure should be maintained as high as practicable, and never less than 75 pounds, in which case good nozzles become more essential for perfect work. To maintain this pressure will require constant hard work, and the tendency will be to allow the pressure to lighten. Except in spraying the tops of trees the nozzle men should never ride in the wagon, even while spraying the smallest trees. In order to reach the inner branches and the underside of the fruit and foliage the operator must spray from the ground, where he is free to walk around and under the trees. Many failures result from attempts to spray trees from the wagon as the outfit is being driven by.

The question is frequently asked, especially by persons not much experienced in spraying, as to the proper quantity of spray required per tree. This information is not only an index to the thoroughness of the spraying that is being done, but is especially useful in arriving at an estimate of the amount of spray chemicals to be purchased.

The quantity of liquid to be used on trees and foliage naturally varies with the size of the tree. For orchards just coming into bearing and with average-sized trees 8 to 10 years old, a proper manipulation of the nozzle should insure thorough spraying with 3 or 4 gallons per tree. For average-sized trees 12 to 15 years old the amount of spray required per tree would be from 5 to 7 gallons, and for older trees a larger quantity will be required, all varying with the size of the opening in the nozzle used and the rapidity with which the work is done. Very old trees of considerable height and spread of limbs often require from 10 to 15 gallons per tree to insure a thorough treatment.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued April 20, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 493.

THE ENGLISH SPARROW AS A PEST.

BY

NED DEARBORN,
Expert Biologist, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., February 20, 1912.

Sir: I have the honor to submit herewith and to recommend for publication as a Farmers' Bulletin a report entitled "The English Sparrow as a Pest," by Ned Dearborn, assistant in the Biological Survey, which is designed to supersede No. 383 of the same series. Introduced into America only about 60 years ago, the English sparrow in this comparatively short period has overspread most of the United States and has extended its range even into southern Canada. The bird has many objectionable habits and few redeeming qualities and, as its general extermination is out of the question because of the necessary expense, its numbers should be reduced so far as possible. The chief aim of the present bulletin is to describe the best methods of effecting this reduction of numbers. Trapping, wherever practicable, is recommended above all other methods, more particularly as English sparrows form an excellent and nutritious article of diet.

Respectfully,

Henry W. Henshaw,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
  Distribution 5
  Economic status 5
  Localization 6
Aiding native birds against the English sparrow 7
Driving sparrows from roosts 9
Prevention of increase 9
Methods of destroying 9
  Catching on nests 9
  Shooting 10
  Trapping 10
    Nest-box traps 11
      Tesch trap 11
    Bait traps 12
      Sieve trap 12
      Miller trap 13
      Funnel trap 17
  Poisoning 20
English sparrows as food 23
Summary 24

ILLUSTRATIONS.

Page.
FIG. 1. English sparrows 7
2. Nest box for the interior of buildings 8
3. Nest box opening at the top 9
4. Nest box opening at the bottom 10
5. Tesch nest-box trap 11
6. Sections showing construction of Tesch nest-box trap 12
7. Sieve trap 13
8. Miller trap 14
9. Top of Miller trap 15
10. Details of Miller trap 16
11. Funnel trap 17
12. Outline of funnel trap 17
13. Pattern for first funnel 18
14. Pattern for second funnel 19
15. Diagram for cutting out the parts of a funnel trap 36 by 18 by 12 inches 20
16. Diagram for cutting out the parts of a funnel trap 48 by 24 by 15 inches 21
17. Receiving box for removing sparrows from traps 21

THE ENGLISH SPARROW AS A PEST.

INTRODUCTION.

DISTRIBUTION.

The English sparrow was introduced into America a little more than 60 years ago, and is now distributed over nearly all of the United States and southern Canada. This rapid dissemination is a result of the bird's hardiness, extraordinary fecundity, diversity of food, aggressive disposition, and almost complete immunity from natural enemies.

ECONOMIC STATUS.

The English sparrow among birds, like the rat among mammals, is cunning, destructive, and filthy. Its natural diet consists of seeds, but it eats a great variety of other foods. While much of its fare consists of waste material from the streets, in autumn and winter it consumes quantities of weed seed and in summer numerous insects. The destruction of weed seed should undeniably count in the sparrow's favor. Its record as to insects in most localities is not so clear. In exceptional cases it has been found very useful as a destroyer of insect pests. For example, during a recent investigation by this bureau of birds that destroy the alfalfa weevil in northern Utah, English sparrows were feeding their nestlings largely on weevil larvæ and cutworms, both of which are very injurious to alfalfa. In this case the sparrows, attracted by grain in the fields and poultry runs and by the excellent nest sites afforded by the thatched roofs of many farm buildings, had left the city and taken up their abode in the country where the weevil outbreak subsequently occurred. Unfortunately, however, farmers can rarely expect such aid against their insect foes. Wherever this bird proves useful, however, it is entitled to protection and encouragement in proportion to its net value.

Under normal conditions its choice of insects is often unfavorable. Out of 522 English sparrow stomachs examined by the Biological Survey,[1] 47 contained noxious insects, 50 held beneficial insects, and

---

[1] U. S. Department of Agriculture, Division of Economic Ornithology and Mammalogy, Bulletin 1, The English Sparrow in North America, p. 143, 1889. An exhaustive account now out of print.

31 contained insects of little or no importance. The bulletin just referred to shows conclusively that, aside from the destruction of weed seed, there is, in general, very little to be said in the sparrow's favor.

On the other hand much is to be said against the bird. It destroys fruit, as cherries, grapes, pears, and peaches. It also destroys buds and flowers of cultivated trees, shrubs, and vines. In the garden it eats seeds as they ripen, and nips off tender young vegetables, especially peas and lettuce, as they appear above ground. It damages wheat and other grains, whether newly sown, ripening, or in shocks. As a flock of 50 sparrows requires daily the equivalent of a quart of wheat, the annual loss caused by these birds throughout the country is very great. It reduces the numbers of some of our most useful and attractive native birds, as bluebirds, house wrens, purple martins, tree swallows, cliff swallows, and barn swallows, by destroying their eggs and young and by usurping nesting places. It attacks other familiar species, as the robin, wren, red-eyed vireo, catbird, and mocking bird, causing them to desert parks and shady streets of towns. Unlike our native birds whose place it usurps, it has no song, but is noisy and vituperative. It defiles buildings and ornamental trees, shrubs, and vines with its excrement and with its bulky nests.

The evidence against the English sparrow is, on the whole, overwhelming, and the present unfriendly attitude of the public towards it is reflected in our State laws. Nowhere is it included among protected birds.

LOCALIZATION.

Although English sparrows are widely distributed as a species, individuals and flocks have an extremely narrow range, each flock occupying one locality to which its activities are chiefly confined. This fact is favorable to their extermination, for when a place has once been cleared of sparrows some time elapses before it is reoccupied. This tendency to remain on special territory was well shown during a recent experiment with a flock in a small city garden. During the fall steady trapping reduced the resident flock in the garden to a dozen individuals, 274 birds having been trapped. The survivors were poisoned. Though another flock lived in the street just beyond the fence, the garden was sparrow free for three months. In the following spring a few sparrows appeared, but were soon trapped. After this the garden continued throughout the summer without a resident flock, and only rarely was it visited by sparrows from other parts of the neighborhood.

AIDING NATIVE BIRDS AGAINST THE ENGLISH SPARROW.

One of the greatest objections to the English sparrow is its aggressive antagonism toward the small native birds, especially those familiar species which, like itself, build their nests in cavities. Nest boxes provided for bluebirds, martins, or wrens—birds both useful and pleasing—too often fall into the possession of this graceless alien, either by the right of discovery or by piratical assault. Fortunately it is possible to aid the native birds by selecting suitable nest boxes. Thus, a box having an entrance 1 inch in diameter will admit house wrens, but not sparrows. Boxes for larger birds, as

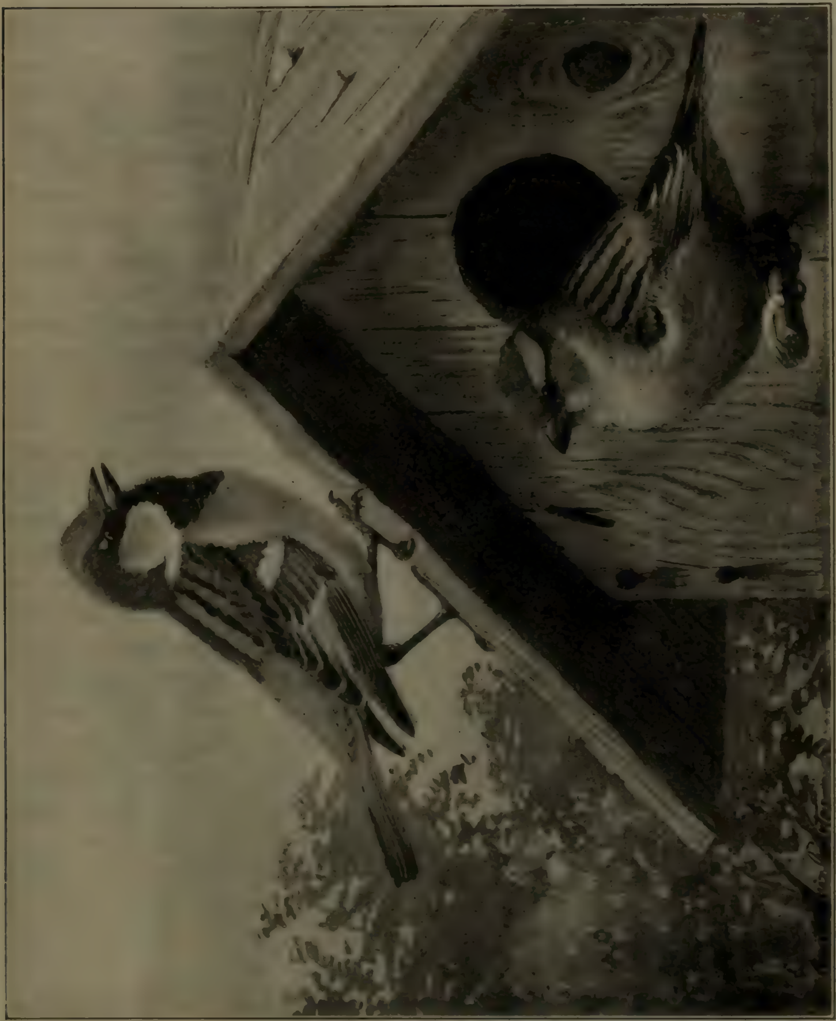


FIG. 1.—English sparrow, male and female, showing the manner in which they take possession of nesting boxes provided for native birds.

illustrated in figures 2, 3, and 4, may be constructed so that unwelcome tenants can be readily evicted and at the same time acceptable to more desirable species. When a sparrow has had its nest and eggs removed from a box, it not only as a rule seeks another place for its next nest, but is likely to avoid that type of nest box in future.

Figure 2 represents a nest box designed for the interior of a dilapidated building, a hole being cut in an outer wall of the building to form the entrance. The box illustrated in figure 3 is intended to be hung on the outside of a building or on a tree where it may be readily examined. Its floor is 6 inches square and its height at the eaves 8 inches. The roof is cross cleated on the underside and hinged at the top. If it is desired to place such a box where it will be out of reach, it may be constructed, as shown in figure 4, with the bottom hinged instead of the roof. In this case a light pole may be used to open and close the box and to dislodge sparrow nests. As the cost of such boxes is slight, enough should be provided to accommodate all the resident sparrows at once, in order that their nests may be broken up and the birds compelled to seek other quarters as early in the breeding season as possible. All nest boxes designed to be occupied by native birds should be carefully built to avoid warping of parts and consequent drafts of air.

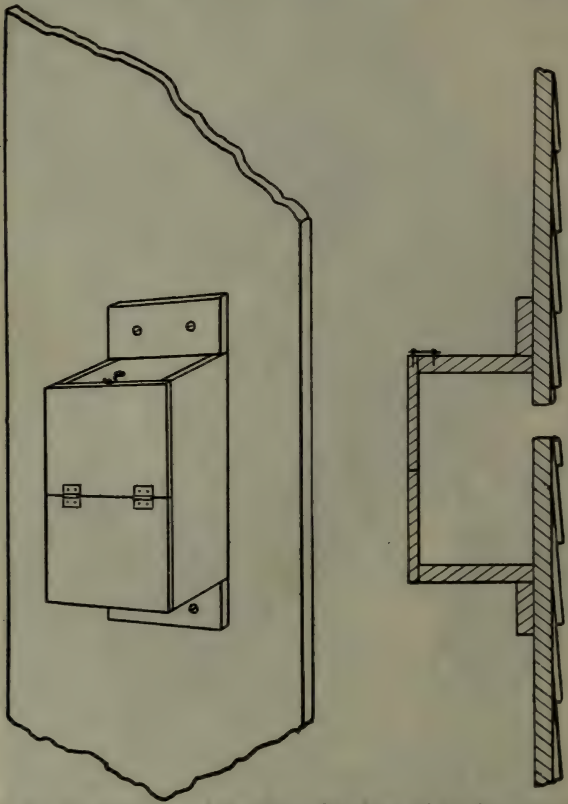


FIG. 2.—Perspective and sectional drawings of an improvised nest box for the interior of buildings.

DRIVING SPARROWS FROM ROOSTS.

Sparrows frequently become a nuisance by roosting in ornamental vines and in crevices about buildings. If scared out late at night, several nights in succession, they will usually desert the roost. A stream of water from a garden hose is a potent ejector, particularly on frosty nights. Where water is not available small Roman candles may be employed.

Though sparrows may be driven from a given neighborhood, the relief thus obtained is only temporary, and has the further objection that the nuisance is simply transferred elsewhere. More drastic action is therefore preferable.

PREVENTION OF INCREASE.

The most effective method of preventing the increase of sparrows in a locality is to destroy their nests at intervals of 10 or 12 days throughout the breeding season. In a town of 4,000 inhabitants, where this method of attack has been practiced during the past four years, 20,000 eggs have been destroyed and the number of sparrows has been greatly reduced. This work, however, should not be entrusted to boys or persons unfamiliar with the native species, as otherwise valuable birds may be destroyed under the belief that they are English sparrows. Occasionally they build large covered nests in trees, but as a rule they build open nests in bird houses, electric-light hoods, cornices, waterspouts, and similar places. While it is often difficult to reach nests by hand, they can usually be torn down by means of a long pole having an iron hook at the tip. By concerted and continuous efforts to destroy every nest after the eggs are laid, the numbers of English sparrows in any locality may be rapidly reduced.

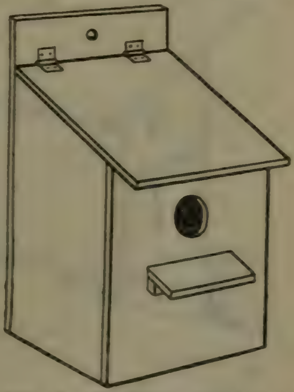


FIG. 3.—Nest box opening at the top.

METHODS OF DESTROYING.

CATCHING ON NESTS.

The sparrow's habit of nesting in cavities can be turned to account against it. By providing one-room bird houses, similar to those illustrated in figures 3 and 4, or even packing boxes or tin cans, and putting them in trees or on poles or buildings at a height of about 10 feet, the birds may be captured after dark with a long-handled net. The net should have a deep bag and a small hoop. After the net has been quietly placed over the entrance, a few raps on the box will send the occupant into it. By distributing a number of nest boxes about orchards, shade trees, and outbuildings, and catching the sparrows that occupy them, the work of extermination may be carried on at a season when other methods are least effective.

SHOOTING.

Sparrows are accustomed to feed in close flocks, and when thus assembled in favorable places a large number may be killed by a charge of No. 10 shot. The best way is to scatter grain over long, narrow areas and shoot the sparrows at these baiting places. Where sparrows infest poultry yards, the bait may be placed on a horizontal board, supported at such an elevation that the birds can be shot without danger to the poultry.

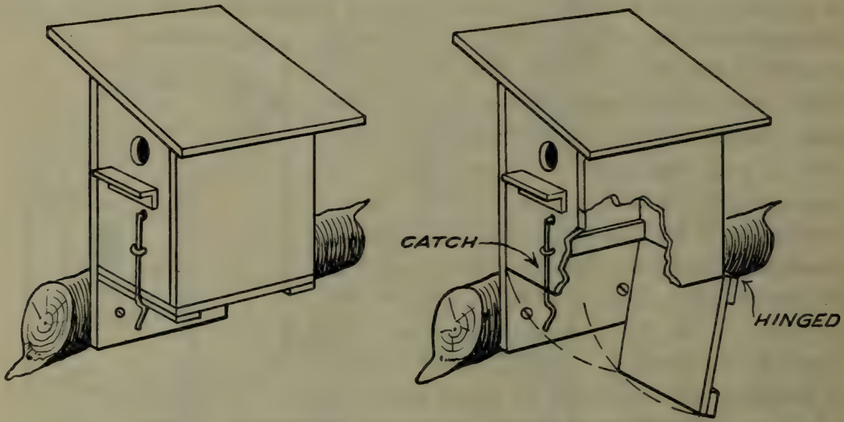


Fig. 4.—Perspectives of a nest box opening at the bottom.

TRAPPING.

In a general campaign against English sparrows, a vigorous and widespread attack is absolutely essential. The problem is not to drive them away from a certain locality, but to accomplish as nearly as possible their complete extermination. As each city square has a sparrow population of its own, which must be destroyed there if at all, certain effective methods of destruction are out of the question. Neither law nor public sentiment will allow the use of firearms or the unrestricted use of poison. The use of traps therefore is strongly recommended. Besides being safe to employ, properly designed sparrow traps have other advantages. They permit the use of sparrows for food, as they leave the flesh uninjured, and these birds may be kept alive, like poultry. The fact that native birds, when caught in such traps, can be liberated unharmed, is particularly important in suburban localities.

Sparrow traps may be classified, according to their nature, as nest-box traps and bait traps. Inasmuch as sparrows usually feed in flocks, but approach nest boxes only singly or in pairs, the annual catch of a bait trap will exceed that of a nest-box trap many fold. During the breeding season, however, nest-box traps are decidedly useful.

NEST-BOX TRAPS.

A nest-box trap, as its name implies, looks like an ordinary nest box. The weight of a bird entering such a trap puts into operation a mechanism which catches the bird and sets the trap for another. There are a number of devices to accomplish this. In designing a nest-box trap one should bear in mind that English sparrows, like other birds, dislike drafty quarters, and that a mechanism delicate enough to be operated by a sparrow's weight is likely to get out of order unless the parts are few and well protected from the weather.

Tesch trap.—Probably the simplest nest-box trap yet designed is the one illustrated by figure 5. The trap described below is a modification of the one invented by Mr. Charles H. Tesch, of Milwaukee, Wis., who furnished plans of his trap and kindly placed at our disposal the results of his experiments. With his trap Mr. Tesch caught sparrows bent on finding a home as fast as they came along. The essential parts of the trap are: (1) A box, (2) a tipping chamber within the box, (3) a down spout below it, and (4) a bag at the lower end of the down spout. The dimensions of the several parts are given in figure 6. The tipping chamber is made of tin, the down spout of wood or tin, the box of wood. The roof board is cleated across the ends, and also lengthwise between the cross cleats, for the attachment of the sides, as shown in the right-hand drawing, figure 6. The close weave of a 2-bushel bag makes it suitable for the lower end of the down spout. One of coarser fabric would allow a draft through the spout and thus detract from the efficiency of the trap. In building this trap the front wall is the last piece to go in place. It is fastened there by screws, so the trap can easily be overhauled. It is a good plan to fasten with shellac a few feathers or bits of hay

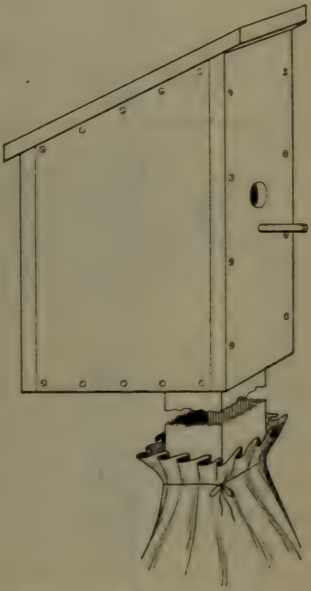


FIG. 5.—Tesch nest-box trap.

to the floor of the tipping chamber near the rear end to excite the interest of sparrows and hasten their entrance.

BAIT TRAPS.

The selection of a bait trap depends somewhat upon the conditions under which it is to be used. Where food is plenty, as in stable yards, poultry runs, and open markets, sparrows have no incentive to run risks; and under such circumstances a trap to be effective must be simple so as not to excite suspicion.

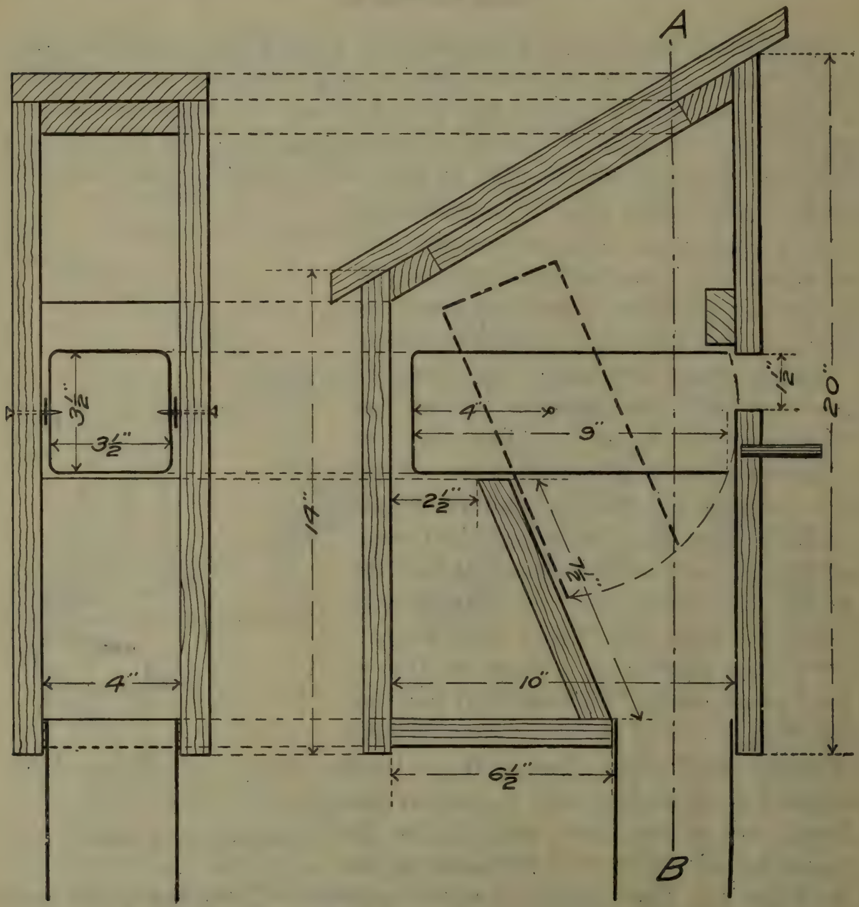


FIG. 6.—Sections showing construction of Tesch nest-box trap.

Sieve Trap.—The sieve trap shown in figure 7 is adapted for service where food is abundant. In the duck yards of the National Zoological Park, Washington, D. C., it is the only trap that has proved successful. It consists of a shallow box not less than 4 feet square, open on one side, covered with woven wire on the other, and having a small door near one corner. In setting this trap, one side rests on the ground, which is carefully smoothed where the trap will fall, while the opposite side is supported by a stick 18 inches long. Near the upper end of this stick is attached a long cord, and between the top of it and the edge of the trap (see fig. 7) is placed a chip. By setting the trap over bait and pulling the cord from a sheltered point of observation numbers may be caught. Instead of the box described above, by which the birds are taken alive, an old door or similar device may be employed as a deadfall. In either case the trap should be kept set and baited until the sparrows are not afraid to go under it. During this interval, to avoid accidents to creatures for which it is not intended, as well as to insure stability, it may be supported by a stake driven into the ground instead of by the stick used to spring it. Although the sieve trap is easy to construct and effective in operation, it has the disadvantage that someone must be on hand to pull the string at the proper instant.

Miller Trap.—The trap shown in figures 8, 9, and 10 was designed by Mr. Charles W. Miller, director of the Worthington Society for the Study of Bird Life, who has kindly furnished photographs and drawings showing its construction and has given suggestions for operating it. With one of these traps over 300 sparrows were caught in less than three months on the society's grounds at Shawnee on Delaware, Pa. It is especially adapted to poultry and pigeon yards, where it can be permanently installed. The poultry or pigeons are fed in the trap, the door being left open until sparrows are accustomed to feed there with them. Later the door is closed and by putting a little bait on the shelf and considerable on the ground inside, the sparrows are enticed to enter through the open corners at the top (fig. 10–*a*). After they have learned the way in and out over the shelf, the corners are closed. The sparrows now enter between the partitions (fig. 10–*b*, *b*) and are unable to return. Captives are removed from this trap by means of a short-handled net, from which they can be taken by hand. A few birds should be left in the cage as decoys. Captives are removed and the decoys supplied with food and water at dusk when outside birds are at roost.

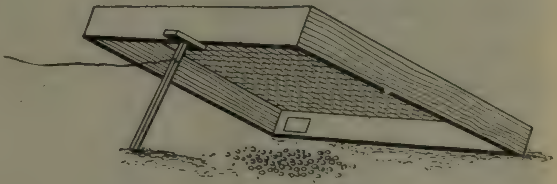


FIG. 7.—Sieve trap.

The construction of the Miller trap may be described under four heads: (1) The cage, (2) the frame, (3) the partitions, and (4) the shields. Figure 10 shows the skeleton of this trap without the wire netting. This should be painted green or gray before the netting is applied. Regular aviary netting of 1 by ¾ inch mesh, or poultry netting of ¾-inch mesh, may be used. The door has a hook on each side and spring hinges. Around the top of the cage extends a shelf (fig. 10–*c*) about 8 inches wide.

The underside of the frame (fig. 10–*d*) is perfectly flat all the way around, in order that the partitions may be attached at a uniform height. The ends of two opposite sides extend 6 inches beyond the square to allow the supporting blocks to be placed where they will not hinder the entrance of sparrows when the corners are open (fig. 10–*f*). The outside measurement of the frame is an inch larger all the way around than the inside measurements of the shelf. After the frame has been painted and covered with wire on the uneven side, it is placed in its final position with relation to the shelf, but without the supporting blocks, and is marked by a pencil drawn along the inner edge of the shelf to show the position for the outer edges of the partitions.

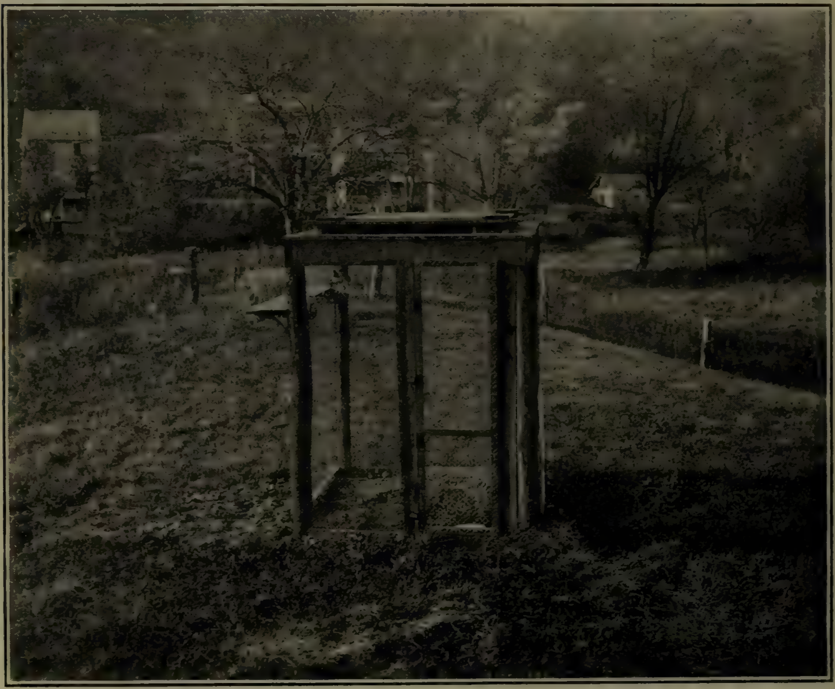


FIG. 8.—Miller trap.

The partitions are sheets of tin 5 inches wide and 6 inches long, having a flap turned over at the top for attachment to the frame and another flap on the outer edge for attachment to the shelf (fig. 10–*b*).

As the sides of the frame are 6 inches wide and the shelf extends inward beneath them 1 inch, the inner edges of the partitions will come even with the inner edge of the frame. The partitions are first nailed to the frame, 2 inches apart, beginning at the middle of each side. The side flaps are nailed to the shelf after the frame has been fastened in position on the corner blocks, which are 2½ inches high. The entrances are thus 2 inches wide and 2½ inches high. The shields are strips of tin nailed to the inner edge of the frame, and extending below it 4½ inches in contact with the inner edges of the partitions, to prevent sparrows in the trap from escaping (fig. 10–*e*). Both shields and partitions should be painted to prevent rusting. The corners between the series of entrances (fig. 10–*a*) are closed by pieces of tin or thin board hinged or otherwise arranged so as to be easily opened when sparrows are to be enticed to enter.

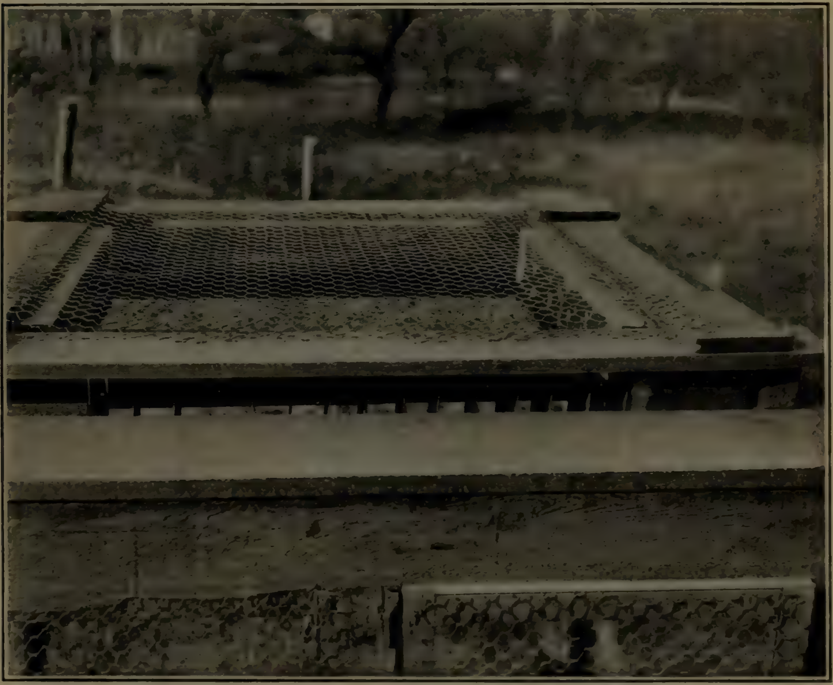


FIG. 9.—Top of Miller trap.

In case several traps are to be built, it will be advantageous to use unit trap tins (fig. 10–*Ah*), held in place by way plates (fig. 10–*Ak*), instead of separate partitions and shields. In this case, as unit trap tins can be removed from a way plate at any time, the corners may be closed permanently by the blocks supporting the frame, the projecting ends thus being unnecessary.

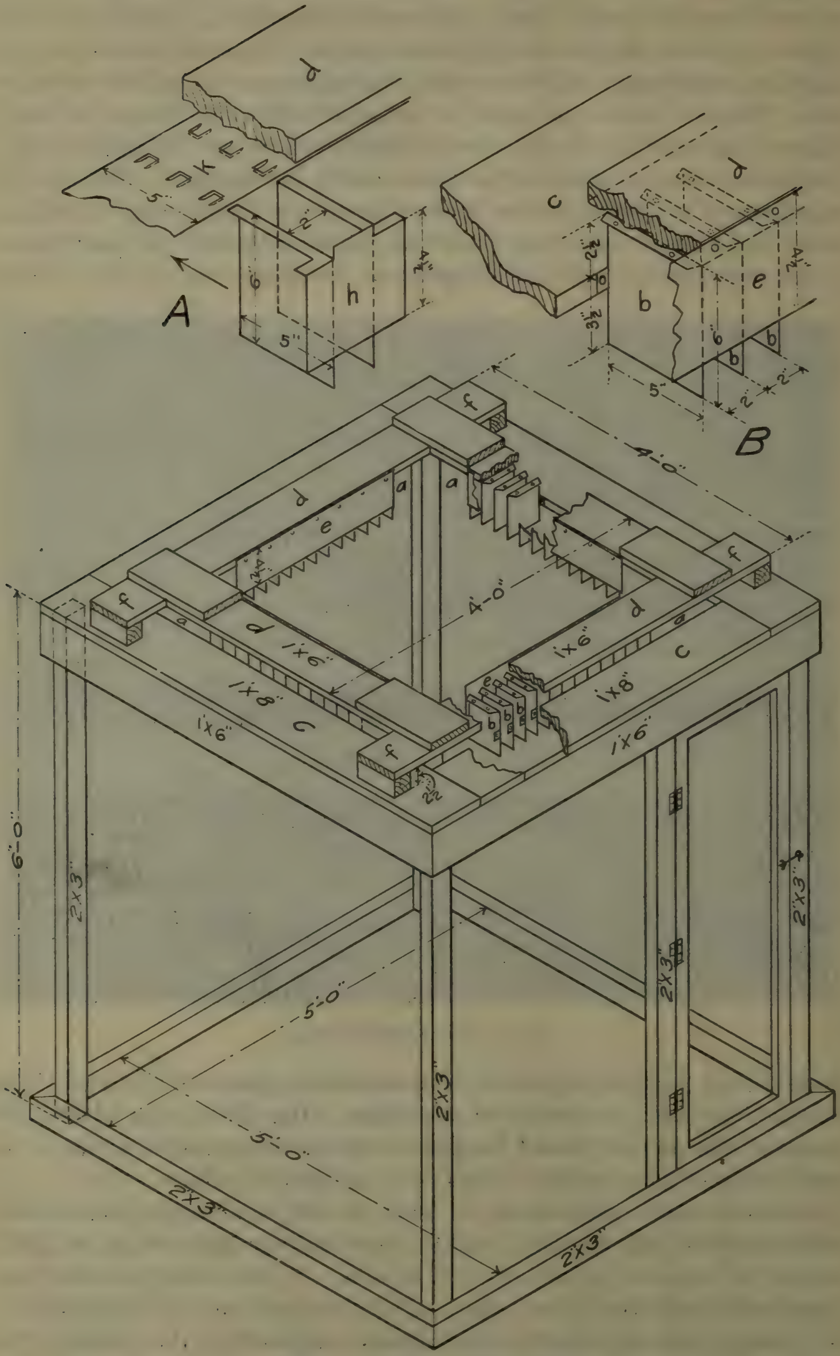


FIG. 10.—Details of Miller trap.

Funnel trap.—When extensive trapping is undertaken, the traps employed must fulfill certain requirements in addition to ultimate efficiency. Especially important are simple and prompt action, portability, and cheapness, all of which are found in the funnel trap. (Fig. 11.) Numerous experiments show that funnel traps usually make a catch on the first day they are set. This trap has no loose parts to become disarranged and requires no tools to keep it in order. Although somewhat bulky, it weighs but little, and when painted green or gray is inconspicuous. It is easy to construct, and the cost of material is slight. The funnel trap has been tested on the Agricultural Grounds in Washington with excellent results, and one sent for trial to the Missouri Botanical Gardens at St. Louis during the

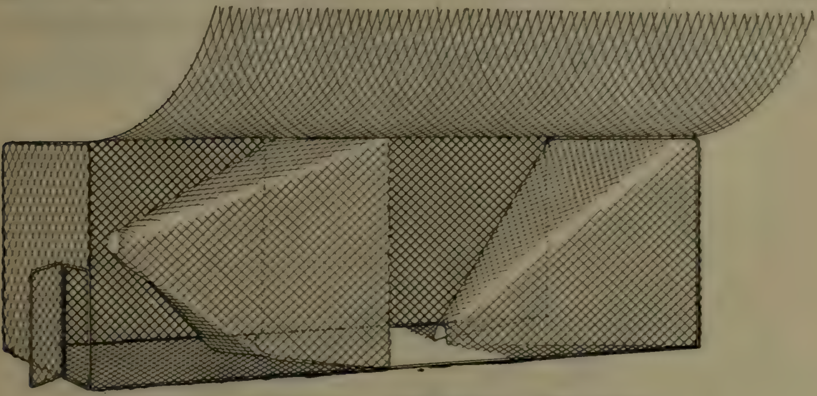


Fig. 11.—Funnel trap. (Side raised to show interior.)

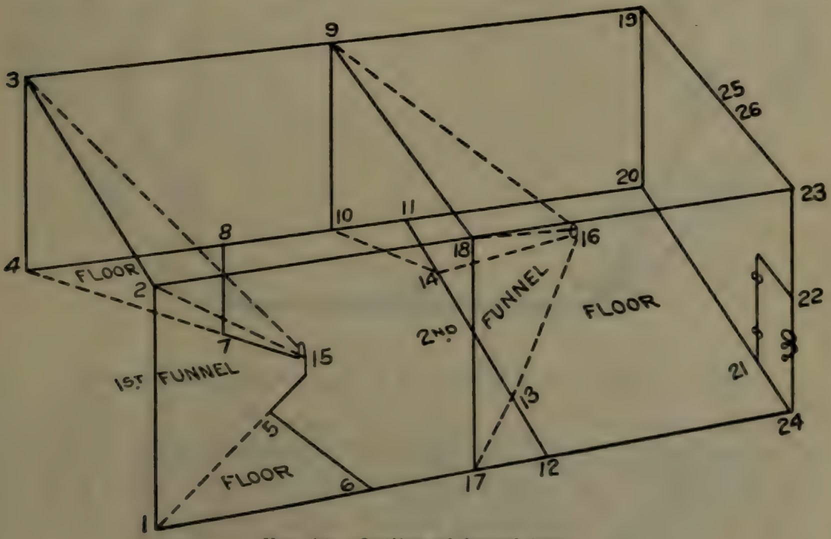


Fig. 12.—Outline of funnel trap.

past summer caught 300 sparrows in six weeks. Its usefulness in a city garden has already been referred to under "Localization."

The essential parts of this trap are: (1) A half funnel leading into (2) an antechamber, which ends in (3) a complete funnel leading into (4) a final chamber. It is made of woven-wire poultry netting of $\frac{3}{4}$-inch mesh and is reenforced around the open end and along the sides at the bottom by No. 8 or No. 10 wire, which is used also around the aperture for the door and around the door itself.

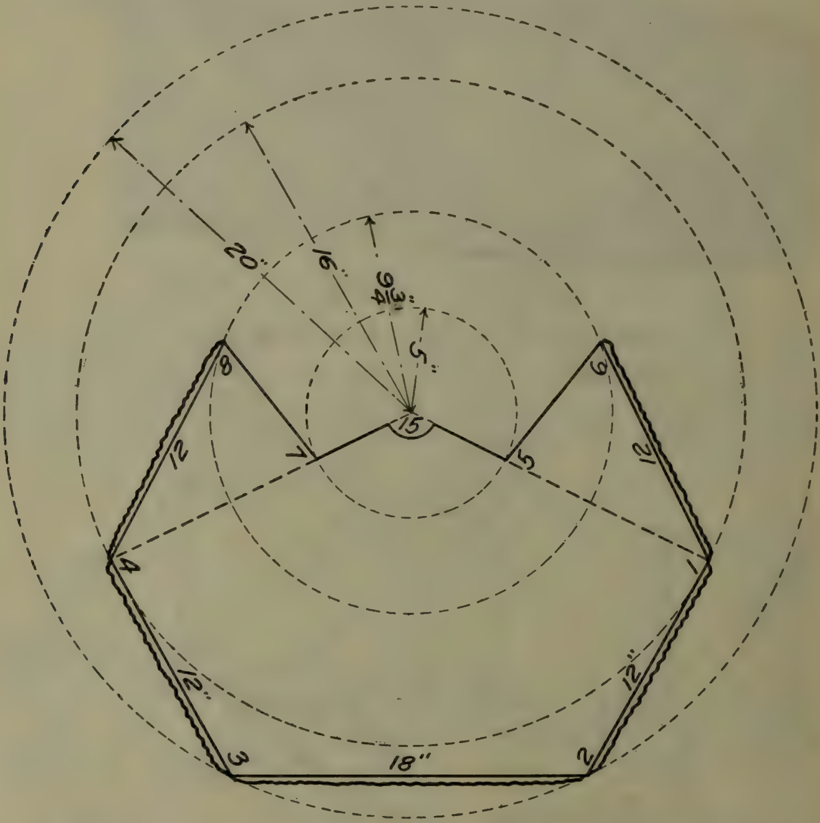


Fig. 13.—Pattern for first funnel of a trap to be 36×18×12 inches.

The angles between the first funnel and the walls of the antechamber are floored with netting, and the final chamber is floored with the same material. The accompanying drawings will enable anybody handy with tools to construct one of these traps in a few hours. These plans are for a trap 3 feet long, a foot and a half wide, and a foot high. At ordinary retail prices the cost of material will be about 70 cents. Paper patterns for the two funnels can be made by first drawing the concentric circles, as shown in figures 13 and 14, and then laying off the straight lines, beginning with the longest.

The wavy outlines indicate that the pattern is to be cut half an inch outside of the straight lines to allow extra wire for fastening the cones to the top and sides of the trap. Figure 15 shows how all the parts of a trap having the above dimensions may be cut from a piece of netting 4 feet wide and 6 feet long. The full lines in this figure indicate where the netting is to be cut and the broken lines where it is to be bent. The numbers at the angles in figures 13, 14, and 15 correspond with those in figure 12, which shows in outline the relation of the different parts as they appear when assembled. A trap of the above dimensions is as small as can be used satisfactorily. Where sparrows are very numerous a larger size is recommended. Figure 16 shows how a trap 4 feet long, 2 feet wide, and 15 inches high may be made from a piece of netting 4 by 10 feet. This is a very good size for parks and large private grounds.

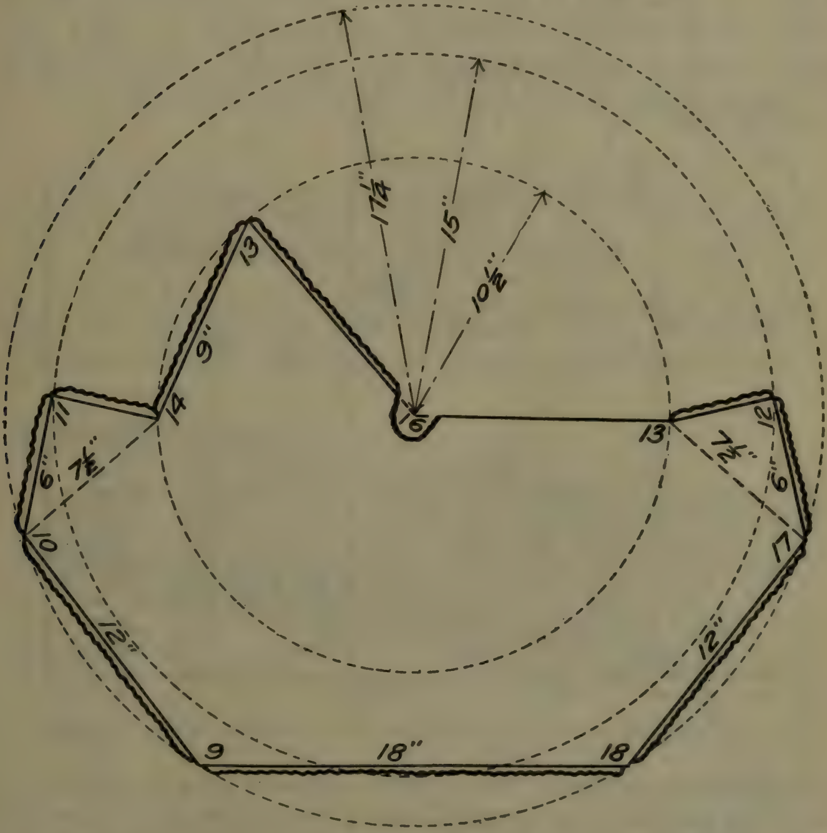


Fig. 14.—Pattern for second funnel of a trap to be 36×18×12 inches.

In setting a funnel trap a place should be selected where sparrows are accustomed to assemble. Often there are several such places in a neighborhood, in which case it is advisable to move the trap daily from one of them to another, because the birds appear to associate the locality rather than the trap with the distress of their imprisoned comrades. Canary seed, hemp seed, wheat, oats, and bread crumbs are excellent baits. The bait should be scattered in the antechamber and first funnel and also, sparingly, outside about the entrance. A live sparrow kept in the trap as a decoy will facilitate a catch. In case native birds enter a trap they may be released without harm. Trapping may begin at any time after young sparrows are able to take care of themselves, which is usually by July 1. Each day's catch should be removed from the trap at nightfall, and if a decoy is used it should be comfortably housed and otherwise cared for when off duty.

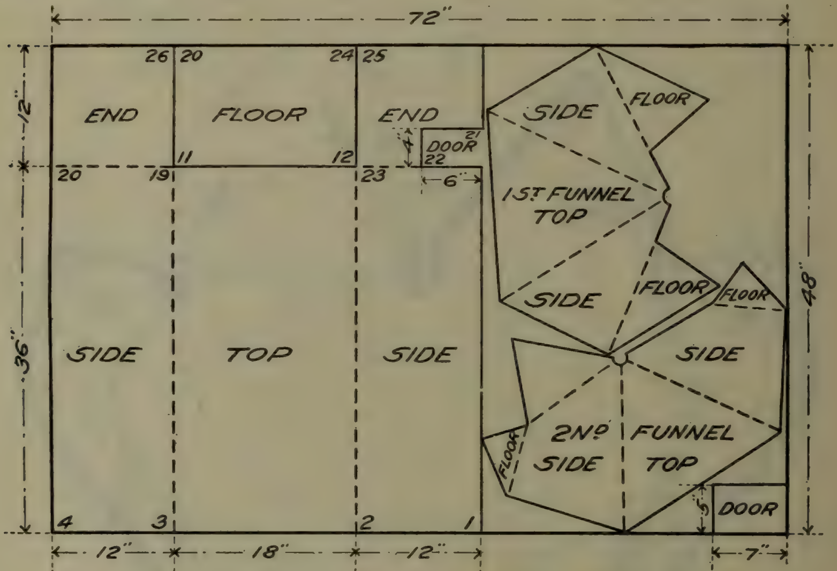


FIG. 15.—Diagram for cutting out the parts of a funnel trap 36×18×12 inches.

In removing sparrows from either a funnel or a sieve trap the receiving box shown in figure 17 will be found useful. It should be about 6 inches square and 18 inches long, inside measurement. The door, hinged at the bottom and turning inward, is controlled by the part of its wire frame extending through the side of the box to form a handle. The box as it appears in the figure is ready to be placed before the open door of a trap from which birds are to be driven.

POISONING.

Where the use of poison is not prohibited by law it may be employed effectively to reduce the number of sparrows. Of the different poisons tested the most satisfactory is strychnine, which is easy to prepare and acts quickly. Wheat has proved to be a good bait as well as an excellent vehicle for administering the drug. A convenient method of preparing poisoned bait is as follows: Put one-eighth ounce of pulverized strychnine into three-fourths of a gill of hot water, add 1½ teaspoonfuls of starch or wheat flour moistened with a few drops of cold water, and heat, stirring constantly till the mixture thickens. Pour the hot poisoned starch over 1 quart of wheat and stir until every kernel is coated. Small-kerneled wheat sold as poultry food, if reasonably clean, is preferable to first-quality grain, being cheaper and more easily eaten by the sparrows. A 2-quart glass fruit jar is a good vessel to mix in, as it is easily shaken

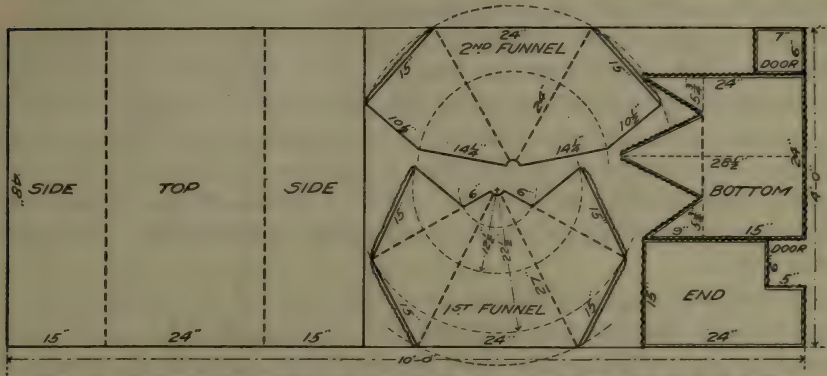


FIG. 16.—Diagram for cutting out the parts of a funnel trap 48×24×15 inches.

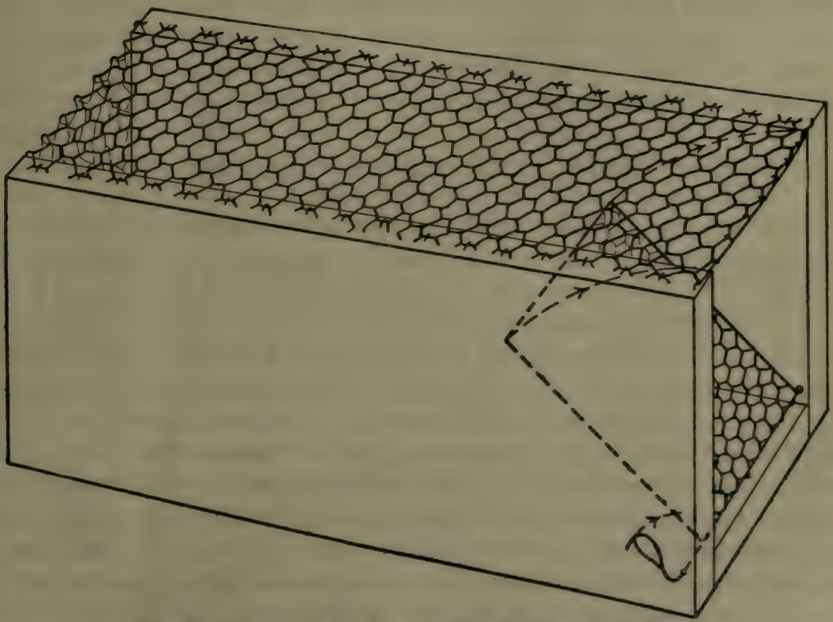


FIG. 17.—Receiving box for removing sparrows from traps.

and allows the condition of the contents to be seen. If the coated wheat be spread thinly on a hard, flat surface, it will be dry enough for use in a short time. It should be dried thoroughly if it is to be put into jars and kept for future use. Dishes employed in preparing poison may be safely cleansed by washing.

Other seeds, as oats, hemp, or canary seed, may be used instead of wheat in the above formula, but they are less economical because much of the poison is lost when they are hulled, though enough of it usually sticks to the mouths of the sparrows to produce fatal effects. As wheat has no hull that a sparrow can remove, it is ordinarily preferable to other seeds. Bread, in thin slices, spread with the strychnine-starch mixture may be used to advantage alternately with seeds.

In case it is impracticable to poison sparrows at their regular feeding grounds, they may be attracted to a suitable place by preliminary baiting. In northern latitudes the best time to put out poison is just after a snowstorm, when other food is covered. The feeding place should be cleared of snow and the poison laid early in the morning. The poison should be well scattered, so that many birds may be able to partake at the same time, since after a few are affected their actions excite the suspicion of their comrades. Usually a few sparrows get only enough strychnine to paralyze them for a few hours, after which they recover. It is important, therefore, to visit the feeding places a short time after distributing poison to prevent such birds from escaping. It is well also to remove dead birds promptly to avoid exciting the suspicious of those that are unaffected. In deciding the amount of poisoned wheat to put out at one time, it is well to estimate the number of sparrows frequenting a feeding place and to allow about 20 kernels for each sparrow. Although 2 kernels of wheat coated with the solution described below have been known to kill a sparrow, 6 or 7 kernels are required to insure fatal results, and much more than a fatal dose is frequently taken. The sparrows that recover after taking poison or that become frightened by the death of comrades, will forsake a feeding place if poison is kept there constantly. If, therefore, one wishes merely to keep them off his land, he can do so by maintaining a supply of poisoned bait for them. On the other hand, if extermination is the object sought, unpoisoned bait should be put out after each killing until the birds have recovered confidence. There is an advantage in having several feeding grounds that may be used in rotation with different kinds of bait. Under these circumstances the sparrows forget their fear of each feeding ground while the others in turn are baited. Only as much poison should be put out as is likely to be eaten in one day, since exposure to moisture reduces its virulence. Any grain coated by the above process and left on the ground will become harmless after a few rains.

As far as practicable sparrows should be poisoned in secluded places where domestic animals will not be endangered. Roofs, back yards, and unused poultry runs are favorable situations. Where there are doves or poultry, sparrows may be induced to feed in small covered pens made of coarsely meshed wire netting, and having the sides raised an inch and a half above the ground. Proximity to low trees, grape arbors, and similar retreats has the advantage that sparrows go to such places between meals, and many dead birds will be found there well away from the bait. If undisturbed, poisoned birds will usually be found within a short distance of where the bait was spread, as death occurs in from 3 to 20 minutes.

Sparrows are so keenly alive to danger that anything which once gives them an unpleasant experience is thereafter consistently avoided. If they take just enough poison to make them sick, only extreme hunger will tempt them to eat poisoned bait again. For this reason the use of poison in connection with traps is advocated. When sparrows are trapped they rarely escape to profit by their experience. In practice it has been found that by the time traps fail, only a small part of the original flock remains. The survivors, although well aware of danger in traps, are as susceptible to the allurements of poisoned bait as ever. Hence the combined use of traps and poison is decidedly more advantageous than either of them alone.

ENGLISH SPARROWS AS FOOD.

In most localities in the United States English sparrows are a pest. There is therefore no reason why the birds should not be utilized for food in this country, as they have been in the Old World for centuries. Their flesh is palatable, and though their bodies are small, their numbers fully compensate for their lack of size. Birds that have been trapped may be kept alive in large outdoor cages, sheltered from storms and cold winds, until they are wanted for the table. It is unprofitable to keep them long, however, as the quantity of grain or other food they require daily amounts to more than half their own weight. A variety of food is necessary to keep them in good condition. Bread, oats, wheat, bran and corn-meal mash, lettuce, cabbage, and tender shoots of sprouting grain are some of the things they relish. A supply of clean water is essential.

To kill mercifully a sparrow that has been trapped, place the thumb nail at the base of its skull and dislocate its neck by hard and quick pressure. To dress it, cut off the legs, the wings at the outer joint, and the neck close to the body; strip off the skin, beginning at the neck; make a cut through the body wall extending from the neck along the backbone till the ribs are severed, then around between the legs to the tail, and remove the viscera. If sparrows are to be broiled, save only the breasts, as this method of cooking so shrivels and parches the lesser parts as to render them worthless. In this case tear off a strip of skin from wing to wing across the back; grasp the wings, in front of the body, in one hand and the neck in the other, and by a quick pull separate the breast from the ribs; turn the breast out of the skin that covers it, and sever the wings at the second joint. The whole operation requires but a fraction of a minute and it can be done by the fingers alone.

Sparrows may be cooked by any of the methods employed for reedbirds or quail. When boned, broiled, buttered, and served on toast they are particularly good and compare favorably with the best kinds of small game.

SUMMARY.

English sparrows are abundant in most of the towns in the United States and in many suburban districts. They are noisy, filthy, and destructive. They drive native birds from villages and homesteads. Though they are occasionally valuable as destroyers of noxious insects, all things considered, they do far more harm than good. Practicable methods of dealing with them include destruction of nests, shooting, trapping, and poisoning. Of these, trapping is unquestionably the best. English sparrows are good to eat, and their use as food is recommended because of their nutritive value and as a means of reducing their numbers.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

○

Issued June 10, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 494.

LAWN SOILS AND LAWNS.

BY

OSWALD SCHREINER, *Soil Scientist*, AND J. J. SKINNER,
Soil Scientist, Bureau of Soils,

AND

L. C. CORBETT, *Horticulturist*, AND F. L. MULFORD,
Landscape Gardener, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., August, 1911.

SIR: We have the honor to transmit and to recommend for publication as a farmers' bulletin the accompanying paper on "Lawn Soils and Lawns," by Dr. Oswald Schreiner and Mr. J. J. Skinner, of the Bureau of Soils, and Prof. L. C. Corbett and Mr. F. L. Mulford, of the Bureau of Plant Industry.

The widespread movement of civic art to improve and beautify cities and towns by park and art commissions, civic associations, and individuals creates a demand for information concerning lawns, their improvement, soil requirements, fertilization, maintenance, soil suited for filling-in or top dressing, and similar questions. It is to supply this general demand for information regarding lawns and lawn soils that the present bulletin is designed.

Respectfully,

MILTON WHITNEY,
Chief, Bureau of Soils.
B. T. GALLOWAY,
Chief, Bureau of Plant Industry.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction.......... 5

General characteristics of lawns.......... 5

The soil.......... 6

Essential characters.......... 6

Adaptability of soils of different texture for lawns.......... 6

    Heavy or clayey soils.......... 7

    Sandy soils.......... 8

Influence of subsoil on lawns.......... 9

Characteristics of a good subsoil.......... 11

Importance of soil moisture.......... 11

Movements of water in soils of different texture.......... 12

Influence of building débris.......... 13

Good drainage necessary in lawn soils.......... 14

Organic matter necessary to make a good lawn soil.......... 15

Effect of organic material in lawn soils.......... 15

Other factors which affect lawns.......... 16

Soil building for lawns, parks, parked embankments, and terraces.......... 17

    Proper and improper filling-in of subsoil material.......... 17

    Hauling in of productive surface soil.......... 18

    Selection of soil best suited for grass growing.......... 19

    The ideal soil.......... 21

    Grading soils for lawns.......... 21

    Preventing erosion on terrace banks.......... 23

    Tile drains in lawn soils.......... 23

Preparation of the soil.......... 25

Fertilizers.......... 26

Grasses adapted to lawn making.......... 27

    For sunny areas.......... 28

    For shady places.......... 33

    For terraces and terrace banks.......... 34

Other ground covers.......... 35

Seed.......... 36

Establishing a lawn.......... 39

    Sodding.......... 40

    When to plant a lawn.......... 41

Maintenance of a lawn.......... 43

    Weeds.......... 43

    Fertilizers.......... 44

    Liming.......... 46

Relation of walks and drives to the greensward.......... 46

Relation of trees and shrubs to a lawn.......... 47

Botanical names of grasses referred to in this bulletin.......... 48

Botanical names of plants other than grasses referred to in this bulletin.......... 48

ILLUSTRATIONS.

		Page.
FIG.	1. Soil auger	9
	2. Three-foot profiles of soils	10
	3. Building débris in lawn soils	13
	4. Careless laying of soil on improperly prepared soil	14
	5. Faulty soil building on public grounds	18
	6. Proper and improper soil grading	22
	7. An eroded terrace bank	23
	8. Harrow for soil preparation	25
	9. Cowpeas as a soil improver in making lawns	26
	10. A good bluegrass lawn	28
	11. A typical bluegrass and white-clover lawn	29
	12. A mixed-grass lawn	30
	13. Bermuda grass in a bluegrass lawn	32
	14. Cross section of improper and proper lawn grading	35
	15. A bank covered with moneywort	36
	16. A bank better than the average on slopes	37
	17. An ivy-covered bank	38
	18. Implement used for cutting sod	41
	19. Crabgrass in a neglected lawn	44

LAWN SOILS AND LAWNS.

INTRODUCTION.

The greensward is the canvas upon which all architectural and landscape effects are produced. A lawn may vary in extent from a few square feet at the side of the steps leading to the brownstone front of the city dwelling to the broad acres of extensive parks. It matters little whether the extent of a lawn be great or small, its inherent qualities are the same, and its intrinsic worth is determined by its character and the manner in which it is kept. Green grass is not only of great economic value, but it is also of great esthetic value. The herbage of the field is the primary dependence of all animal life, and it is the green color, the sweet fragrance, and the soothing effect of nature which come from well-kept greenswards that make them so congenial to man. Grass is nature's balm and healing for all erosive scars. Nature abhors rough edges and broken places, and immediately proceeds to cover such ugly spots with green grass. Man likes to get his feet upon the soil, but, better still, upon the soft, yielding greensward. Rich rugs and carpets do not give the elastic spring that the well-made and well-kept greensward yields.

A lawn is the accompaniment of every effort on the part of man to beautify the surroundings of his abiding place. The great increase of interest in suburban and rural life has caused a corresponding increase of interest in matters pertaining to the making and maintenance of lawns. Suburban railways, the extension of electric lines into the country, and the return of man to natural ways of living are all factors contributing to the growing interest in matters pertaining to lawn making.

GENERAL CHARACTERISTICS OF LAWNS.

In general, a lawn should be beautiful and it should be useful. Its beauty depends upon the contour of the land, the color and texture of the grass, and the uniformity of the turf. The use of the lawn is to provide a suitable setting for architectural adornment and landscape planting. Every device should be employed when working with small areas of ground to give the lawn as great extent as possible. The buildings should be well back, the foundation not too high, and the grading of the ground should be slightly convex—that is, a gently convex, rolling surface from the base of the foundation to the street line, rather than concave. A convex surface tends to give the effect of increased area, while a concave surface seemingly shortens the distance. The extent of a lawn is also amplified by preserving as large areas of unbroken greensward as possible. This means the use of trees and shrubs only upon borders or margins of the lawn, rather than a promiscuous dotting of them over the greensward.

THE SOIL.

The ideal soil for a lawn is available in but few cases where it is desirable to establish a greensward. Ordinarily the lawn in which a man is most interested is that immediately surrounding his abiding place. The soil of this immediate locality is, in general, greatly modified because of building operations or necessary grading. The soil with which one has to deal, therefore, is seldom a normal soil of the locality. In general, it is a portion of the surface soil mixed with more or less of the subsoil which has come from excavation in making the foundations of a house. Large lawns and parks are not, as a rule, so subject to difficulties of this kind as are small private grounds. The problem before us, then, is that of converting not a normal but an abnormal soil into a suitable and congenial place for the growing of grasses.

ESSENTIAL CHARACTERS.

A lawn soil should have a good moisture supply at all times. It should be able to take care of excess during the wet season by drainage and during the dry season be able to supply stored-up moisture from its depths. This adequate water supply is the principal factor in grass growth and the one most difficult to control in a poor soil. It is more important than any added fertilizer and can not be compensated for by the addition of any amount or kind of chemical plant food. All suggestions regarding lawn soils, their texture, selection, and manipulation have been made with one end in view—the creating and maintaining of an adequate water supply in as natural a manner as possible. If this water supply is maintained effectually by a normal soil, the natural processes which go hand in hand with it, such as proper bacterial activity, aeration and oxidation, soil sanitation, and the supply of plant food generally, are also sufficient for a healthy growth of a good greensward.

ADAPTABILITY OF SOILS OF DIFFERENT TEXTURE FOR LAWNS.

The soil material consists of several recognizable grades, which can be determined in any given soil by analysis—clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel. It is this difference in the size of soil particles and in the proportions in which they are present in soils that has given rise to the different classes of agricultural soils, such as the clays, clay loams, sands, and sandy loams. This difference determines the texture of the soil. The texture is a particularly important factor in a successful lawn, as it has a very marked influence on the kind of grass or combination of grasses and clovers best suited to the soil; on its ability to hold sufficient moisture to carry the grass through a prolonged drought; on the ease of establishing good natural drainage; on the amount of aeration, and on other requirements. The various percentage relationships of these different grades determine the texture of the soil and the class to which it belongs; that is, they determine whether it is a sand, a loam, or a clay, or an intermediate soil class.

These soil classes fall naturally into two divisions, the heavier and the lighter soils. The heavier soil classes contain comparatively large amounts of the two finer grades of soil material—silt and clay. The lighter soils contain a large percentage of the sand grains, especially the finer sands. In other words, in the heavier soils are found large amounts of silt and clay particles, with vanishingly small amounts of the more sandy grains; in the lighter soils are found large amounts of the sandy grains, with vanishingly small amounts of silt and clay on the one hand and the coarser grades on the other.

The following discussion of different soil classes will be useful as a guide in selecting soils suitable for lawn or park purposes and for the production of lawn soils by proper mixing of two or more soils of different texture.

HEAVY OR CLAYEY SOILS.

Clay soils.—When productive these soils usually make very strong lawn soils, giving a dense sod In the regions suited to the Kentucky blue grass, excellent lawns consisting wholly of this most desirable of lawn grasses are easily obtained. The clay soils are usually, however, more difficult to prepare for lawn purposes, as the handling of the soil requires greater care than the more loamy soils to obtain a good physical condition at the time the seed is started. Liming is often desirable to help loosen the texture, and the plentiful incorporation of organic manure is almost a necessity. In very heavy clays it will often prove advantageous to incorporate a loam or sandy loam with the first few inches.

Clay loam soils.—When well drained and carefully handled, a clay loam is well suited for the establishment of an excellent greensward. It is retentive of moisture in amounts decidedly favorable to a good growth of grass. In the making of lawn soils by mixing, clay loams give good results, especially for mixing with sandy soils.

Silt loam soils.—These soils are ideally adapted to lawn making, but they must have good drainage and be liberally supplied with organic matter.

Loam soils.—These soils, when they have good drainage and contain sufficient organic matter, will maintain a good lawn. When hauled in, due consideration should be given to the nature of the soil or filling already in place, as this becomes the subsoil of the finished lawn.

TABLE 1.—*Average composition of soil materials, showing the proportions of the different-sized particles.*

[Mm.=millimeters.]

Soil classes.	Percentage composition.						
	Fine gravel 2–1 mm.	Coarse sand 1–.5 mm.	Medium sand .5–.25 mm.	Fine sand .25–.1 mm.	Very fine sand .1–.05 mm.	Silt .05–.005 mm.	Clay .005–0 mm.
Clays	1	3	2	8	8	36	42
Clay loams	1	4	4	14	13	38	26
Silt loams	1	2	1	5	11	65	15
Loams	2	5	5	15	17	40	16
Fine sandy loams	1	3	4	32	24	24	12
Sandy loams	4	13	12	25	13	21	12
Fine sands	1	4	10	57	17	7	4

SANDY SOILS.

Coarse sandy soils.—These soils are unsuitable for lawn purposes. Although certain grasses will grow upon them, and where necessary can be used as soil binders, the result produced can hardly be called ornamental. They are too dry and loose for lawn purposes.

Fine sandy soils.—A fair lawn may be established on soils of this class by paying special attention to the preparation of the soil by the introduction of manure or green manure, together with bone phosphates, and lime in some cases, and copious watering during dry seasons. With a clay or clayey subsoil a really good and permanent lawn can be established on such sandy soils without great difficulty, especially when a mixture of suitable grasses is used. Its low water-holding power is its chief drawback. Top dressings of well-rotted stable manure and other fertilizers from time to time are requisite for good results. Lime as a top dressing is also often desirable on sandy soils.

Sandy loam soils.—Such soils make very good lawns when well drained and well supplied with organic matter; and, where underlain by a clay or sandy clay subsoil, they sometimes even rival the clay loam or silt loam in adaptability to lawn grasses. When low in organic matter the deficiency must be made up. Stable manure, forest mold, green crops plowed under, especially the legumes, afford very desirable materials for supplying organic matter. Lime is frequently desirable and often necessary in the soil preparation and as a later top dressing. Bone phosphate should be used in preparing the soil and may be later used as a top dressing.

Fine sandy loams.—These are very similar to sandy loam soils in their adaptability to lawn making and have even a greater water-holding power.

THE INFLUENCE OF SUBSOIL ON LAWNS.

Soils are underlain at different depths in different types by a distinctly different soil layer known as the subsoil. In shallow soils this subsoil, usually of a different texture, but not necessarily so, is sometimes within a few inches of the surface, and is indeed often touched by plow or spade, and thus gradually the soil itself may be deepened and changed in texture. In other cases the soil is quite deep, often many feet, and in arid regions this change in soil material as one goes downward is often not observable at all.

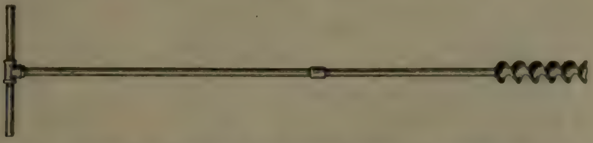


FIG. 1.—Soil auger for collecting soil samples and useful in exploring subsoil conditions in lawns. Such an instrument entirely prevents the disfigurement which would be unavoidable if a larger hole had to be dug in a lawn.

A soil can not be judged for lawn purposes simply by the visible surface or top soil as far as it is ordinarily cultivated or turned by plow or spade. The depth of the surface soil is very important and variable. Soils of widely different agricultural value owe this often to difference of depth alone. The fact that the nature of the subsoil has an effect on the productiveness and suitability of soil for lawn purposes has already been mentioned. Those soils having a clay subsoil are usually stronger soils and better able to maintain a good lawn than those having sandy subsoils. In the sandy soils the better results are always obtained where a good clayey or even clay subsoil occurs.

In figure 2 are shown 3-foot profiles of soil types illustrating different depths of surface soil and nature of subsoils as actually encountered under natural conditions.

The texture of the subsoil is fully as important as the texture of the soil, although the requirements of a good subsoil are usually somewhat different from the requirements of a good top soil. An impervious clay subsoil is utterly unsuited for any crop, and soils occurring above such subsoils are themselves usually poor, but can often be made most productive by laying drainage tiles in the subsoil. The character of the subsoil, its texture, and its distance from the surface are often vital criterions of the natural productiveness and suitability of soils, and hence these factors must also receive consideration in the establishing of a lawn, whether it be by filling in of soil materials or on a soil in its natural position.

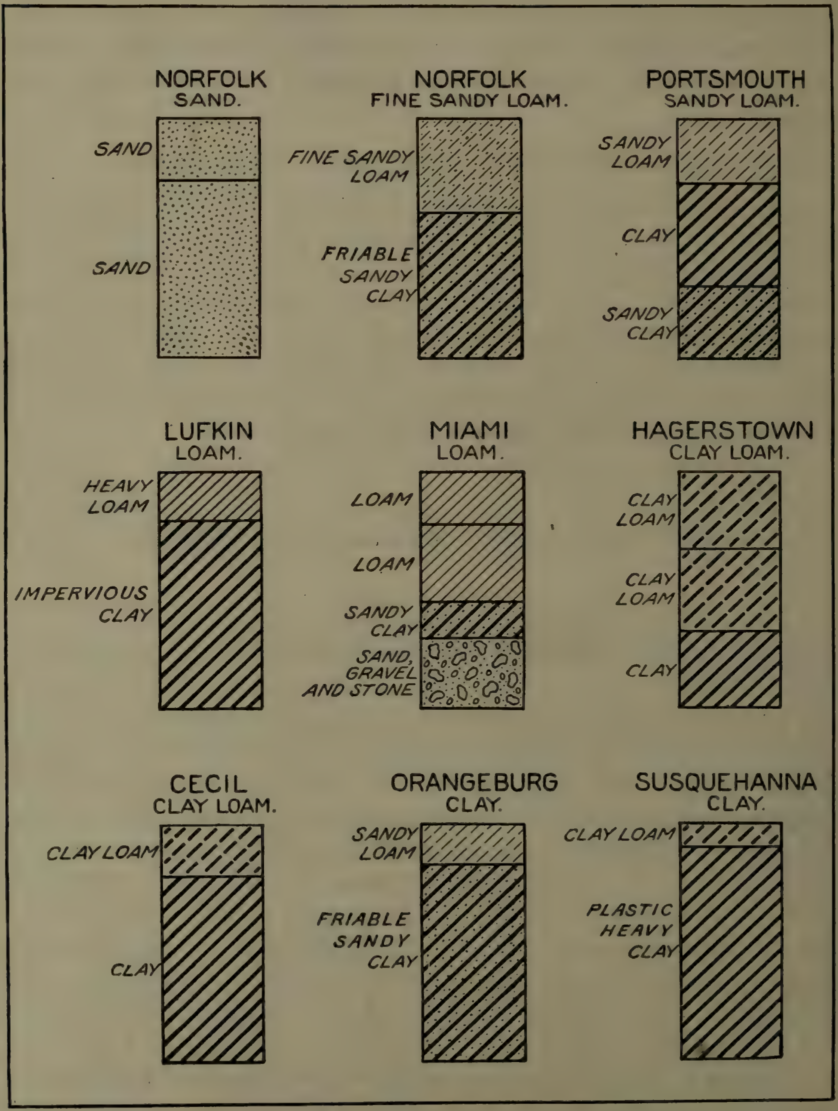


FIG. 2.—Three-foot profiles of soils, illustrating different depths of surface soil and nature of subsoils.

CHARACTERISTICS OF A GOOD SUBSOIL.

In the first place the subsoil of a good lawn soil should not be too near the surface; that is, the soil itself should be a deep soil, never less than 6 inches and preferably as deep as 12 inches or more, for it must be remembered that a good subsoil, even when good as a subsoil, is nevertheless a poor substitute for a surface soil.

There is no doubt that in certain sections of the country some subsoils are harmful when incorporated in a soil, and that while deep plowing is desirable, it is unsafe, after shallow plowing has been carried on for years, to run the plow down and turn up a great mass of subsoil and incorporate this with the soil. In a great many cases it has taken several years to restore the original fertility of the soil. A subsoil should never be used in lawn building without being covered 6 to 12 inches with a good surface soil. The subsoil should resemble the surface soil in its general character. It should be heavier in texture when underlying sandy soils. The subsoil should be moist at all times, yet permit of good drainage. It should contain considerable amounts of water during the wet season, and later, during dry spells, be able to give it up to the surface soil and roots therein. By virtue of a close and firm texture it can draw moisture from a considerable depth. If the subsoil is of bad texture, such as impervious clay, the drainage is bad and the soil consequently cold and wet, unmanageable, and unproductive, or if it consists of a loose sandy material it will be too leachy and consequently too dry, especially during droughts, because no water will be stored in it or drawn up through it from greater depths.

Other bad soil conditions, involving bad drainage, are various hardpan formations. These are usually layers of soil cemented together by lime or iron compounds and are found in some regions in large sheets or pockets, often immediately below the surface soil, thus acting as an effectual barrier to the movement of moisture, either downward or upward. Under such conditions, which are fortunately rare in soils to be used for lawns, grass can not be grown any more than on a cement or other sidewalk buried a few inches under ground.

IMPORTANCE OF SOIL MOISTURE.

The growing grass obtains the products of solution of the soil materials, inorganic and organic, both good and bad, through the medium of the soil fluid. From the soil fluid it obtains the potassium, calcium, magnesium, phosphorus, nitrogen, and other elements necessary for its nutrition. These it removes from the soil fluid by the process of absorption by the growing root, and when the soil sanitation is good this absorption proceeds in a normal manner, but when it is imperfect, due to bad drainage or accumulation of products unfavorable to growth, the absorption of the plant is seriously interfered with. Most important, however, is the water of the soil fluid itself, for this is absolutely necessary for grass growth. It is the plant's chief source of hydrogen and oxygen, which, together with carbon obtained from carbon dioxide of the air, forms the larger part of the plant's total dry substance. The water, moreover, forms the larger part of the grass itself when green. This fact tends to emphasize the great importance of soil fluid to the growing grass and further shows the absolute dependence on it for establishing a good growth of grass. The importance of the soil condition and texture in influencing the amount and movement of this soil fluid becomes, therefore, of paramount interest, as through it the life of the lawn is sustained and maintained.

The greatest drawback to the establishing of a good lawn is an inadequate water supply during periods of drought, and the chief function of a good lawn soil is to furnish an adequate water supply—to moderate excessive rainfall by good drainage and yet hold sufficient water to allow the lawn to live through periods of drought. The roots of lawn grasses are comparatively close to the surface, not penetrating more than a few inches into the soil except where excellent soil conditions exist. The greater the depth of surface soil the deeper will the roots penetrate and consequently the greater the amount of soil fluid directly available. Ordinarily, however, the soil accessible to the roots will, even in a soil with good water-holding power, not contain sufficient water to last through a considerable drought, and it is therefore necessary that the soil be able to draw moisture from lower lying strata. A heavy retentive subsoil acts as a soil reservoir to supply the surface soil with water during dry spells.

MOVEMENTS OF WATER IN SOILS OF DIFFERENT TEXTURE.

The movements of soil fluid are chiefly upward and downward, any lateral movement being extremely slight. The downward movement occurs as a result of rainfall, melting snow, or other addition of water to the surface. This downward movement is usually rapid and varies according to the texture and structure of the soil, which also determines the amount of water retained in the soil. Later, by evaporation from the soil or through transpiration by the grass, this moisture in the soil is gradually dissipated into the atmosphere and a movement of soil fluid is set up within the soil whereby moisture moves from the wet subsoil into the surface soil through the capillary spaces made by the soil grains or aggregates of grains. In loose, sandy soils the moisture descends rapidly, reaches the water level below the soil and subsoil, and begins its movement laterally from the soil as seepage water, finding outlets into ditches, streams, and other watercourses, comparatively little being retained in the moisture films around the sand grains. During dry periods this retained moisture is soon depleted, and owing to the coarseness of the grains the movement upward is not sufficient to keep up with the demand in the surface soil, the connection with the subterranean water is broken, and a dry subsoil is the result, thus causing an impoverishing of the lawn, with ultimate parching and drying out of the grass during the summer months.

In the heavier soils the water does not descend so rapidly nor so completely. Considerable amounts are retained and, when required, move upward to the surface soil. Moreover, the connection between the soil fluid and the low-lying water level is not so easily severed, so that water from considerable depths can be drawn upon to supply the needs of the surface soil.

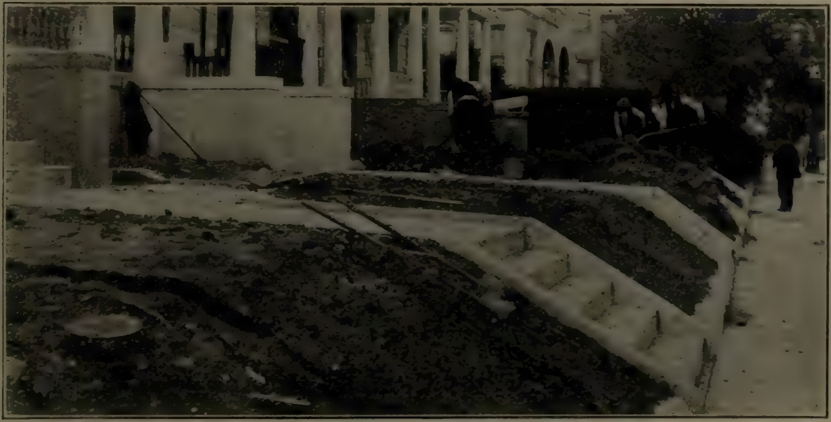


FIG. 3.—Building débris in lawn soil. The presence of bricks, flat tins, boards, and other coarse building débris, found in nearly all small lawns in the cities, is very detrimental to the proper movement of soil fluids.

INFLUENCE OF BUILDING DÉBRIS.

Bricks, flat tins, boards, and other coarse building débris found in nearly all small lawns in the city are very detrimental to the proper movement of soil fluid. The downward movement of water is not seriously impeded by such materials and is probably even facilitated. The moisture moves downward until it encounters a brick, for instance, at a distance of 3 or 4 inches below the soil level. The water meets with no difficulty in getting to the edge of the brick and then goes nearly straight downward, thus leaving the soil immediately below the brick unsupplied from this new water influx. Now, when the opposite movement of soil fluid begins the water moves upward until it encounters the brick, and the soil immediately above the brick, which has in the meantime dried out, remains unsupplied with moisture, so that the grass suffers and dies out during a critical dry spell. Bad spots in small city lawns are more often than not found to be due to some such impediment to the movement of capillary water.

GOOD DRAINAGE NECESSARY IN LAWN SOILS.

The beneficial property of the heavier soils and subsoils which enable them to retain moisture and offer resistance to its free passage presents, on the other hand, a danger. When this resistance, by virtue of too close a texture or lack of structure, becomes excessive the soil becomes, as it were, "waterlogged," producing a wet, cold soil, without aeration and proper life. There is an almost total arrest of the normal functions of the soil and a substituting therefor of an abnormal condition, resulting in the formation of compounds inimical to the growth of grass, so that it dies from the presence of harmful compounds or poor air supply at the roots. Such a condition can be helped or eliminated by proper drainage, such as may be secured by the laying of tiles in the subsoil, whereby the flow of water is facilitated, the air again penetrating, and a normal oxidation and functioning of the soil are brought about. The application of lime aids in forming the clay particles into larger groups, thus giving large spaces between these groups, through which the soil fluid can move with greater freedom. This is often resorted to, and should never be omitted in making lawns on soils having very stiff subsoils. Hardpan

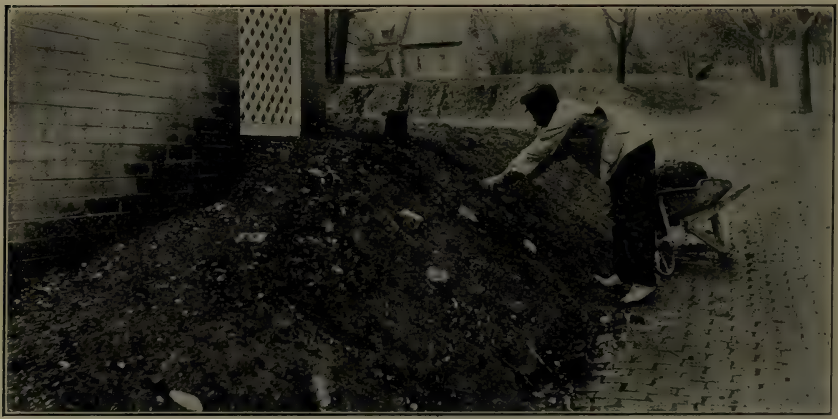


FIG. 4.—Careless laying of sod on improperly prepared soil. The débris is almost as great as the actual soil material, and either through ignorance, indifference, or carelessness this débris is covered over with, at best, indifferent sod, with only one possible result, a poor lawn.

formations and other natural hindrances to the movement of water must also be broken up by subsoiling or other means, as good drainage, like a good water supply, is absolutely essential for a healthy greensward.

ORGANIC MATTER NECESSARY TO MAKE A GOOD LAWN SOIL.

The organic matter is the great promoter of proper structure of the particles to form an arable soil; its influence in the formation of loamy friable soils of good texture and structure is well known. The organic materials of the soil are very important, in that they make soil out of what would otherwise be only a rock powder or sand. By its presence and the changes which take place during its decay the water-holding power of a soil is greatly increased, and hence its presence in lawn soils is especially desirable. It is, however, in the lawn that it is most difficult to introduce organic matter into the soil, and it becomes imperative, therefore, that the lawn soil be made as rich in this important soil ingredient as possible before planting, i. e., when the lawn soil is first prepared. Later, when the lawn is established, organic matter can only be introduced into the soil in the soluble material leached from manure and other surface applications, and the beneficial effects in loosening up soils produced by the decay of the insoluble materials of the manure are, therefore, entirely absent. The decay of manure is usually more rapid in sandy soils than in clay soils, another factor which makes the sandy soils less desirable for lawns.

EFFECT OF ORGANIC MATERIAL IN LAWN SOILS.

The organic materials have a chemical and physiological effect on the lower life in the soil as well as on the grass. In addition to the physical effects already noted, some of the products of change of these organic materials are doubtless directly beneficial to bacteria, promoting their activities, and also directly beneficial to the growing grass. It is likewise certain that some organic soil constituents are directly harmful to grass, preventing its best development, interfering with its root growth and root absorption of soil nutrients to such an extent as to make the successful growth of grass under such conditions impossible.

The application of good organic manures, liming, and drainage are the most potent factors in promoting good soil conditions. Liming has been found to be very beneficial, aiding the destruction of harmful bodies of this nature, both by combining with them and also by oxidizing them to other less harmful, or even beneficial, compounds. Drainage also aids materially in two ways: First, it allows a freer access of air with deeper penetration of healthy roots, which in time promotes oxidation, and thus aids the destruction of unfavorable organic matter; second, it will produce beneficial results by an actual removal of the harmful material in the drainage waters, as well as by eliminating the cause of its formation. The addition of good organic manures will also assist in the destruction of the injurious compounds already in the soil. The introduction of easily decomposed organic matter causes greater bacterial activity and greater oxidation in the soil. The fertilizer salts likewise induce or quicken changes which take place without them only very slowly or not at all.

OTHER FACTORS WHICH AFFECT LAWNS.

It is not possible to state definitely to what extent root excretions may affect lawns, but this much is certain: Plants or soils are affected as the result of the continuous growth of the same plant or by the simultaneous growth of two or more plants. The influence of certain trees or shrubs on the lawn may be, in part at least, ascribed to such a cause. If the excreta of grass itself affects the continuous growth of grass, it is also certain that this effect would show itself more on certain soils than on others, and on a soil suited admirably for the development of grass such an effect would be entirely eliminated, for the good soil conditions would be able to destroy the unfavorable material from season to season and thus prevent an accumulation which would take place in the course of time under less favored soil conditions. The association of different grasses and clovers would no doubt aid in prolonging the natural life of a lawn under conditions which would cause the early decadence of a lawn sown to only a single grass. The influence of weeds in this matter of unfavorable effect of one plant on the other is also considerable, apart from their undesirability in lawns because of their appearance.

As far as lawns are concerned this influence is perhaps most noticed in the relationship of trees and grass, a relationship which is only too often the cause of poor lawns under or in the neighborhood of trees. Bare places under trees are of very frequent occurrence and are usually, and often erroneously, attributed to shade. There can be no question that shade plays an important part in many cases, but usually it is only a contributory factor and the bare places often on closer observation are found to be most developed on the side least subject to shade, and on the lower side so far as drainage is concerned. The retention of washings from the leaves and bark of trees is undoubtedly a factor in the infertility of soils in the vicinity of such trees. This influence of one plant on another of the same kind growing in succession in the same soil, or of the influence of one plant on another of an entirely different kind, and the influence of the soil texture, nature of subsoil, and other chemical, physical, and biological factors upon such plant influences or associations will serve to make clear the many antagonisms between grass and weeds, and grass and trees, shrubs, and other plants so often encountered in lawn building and landscape gardening. Such influences are apt to be observed more generally in soils not well adapted for the purposes for which they are used, owing to faulty texture, bad drainage, poor subsoil conditions, and other defects, so that the nature of the soil becomes really the determining factor.

SOIL BUILDING FOR LAWNS, PARKS, PARKED EMBANKMENTS, AND TERRACES.

Some of the principles of soil building applicable to such cases as involve the alteration of soil already in place, the addition of surface soil over soil already in place, and the filling in and leveling of unsightly and unsuited places, for the establishment of private grounds, city parks, and terraces of many kinds are noted in the following pages. These principles govern all cases where soil is to be transported from one place to another, the object being to establish a greensward on the soil in its new environment. Specific advice or directions applicable to all large civic improvements can not be given on account of the necessarily local nature of the problem. General principles can, therefore, only be emphasized.

PROPER AND IMPROPER FILLING-IN OF SUBSOIL MATERIAL.

The utmost care in supervision should be exercised in regard to the material used in the building of the soils of larger city parks where filling-in is often a necessary step. Had such simple precautions been followed in the past, poor public parks and lawns in public grounds surrounding public buildings of all kinds would not now be encountered. The remarks here made apply only to the last 4 feet or so of filling and not to cases where very deep fillings are made. Building débris, bricks, and other coarse material should be absolutely barred from these last 4 feet.

For the reasons already discussed the soil material which is to serve as subsoil should be preferably of heavier texture than the surface soil available for the lawn, and never of a distinctly sandy nature, if goods results are desired. The heaviest material of the subsoil should be filled in first and as near as practicable distributed evenly over the entire area to be filled in. In large parks each lawn should be considered as a unit. It would seem needless to remark that old sidewalks, cement cellars of former buildings, etc., should first be removed, or at least thoroughly broken up, and yet experience has shown that this precaution is seldom complied with. The lighter material of the subsoil should then be hauled in on top of the first layer and spread out in an even layer. Where the material for the fill is all of the same kind and texture, this precaution is unnecessary, but wherever layers are likely to be formed each should be uniformly distributed over the entire area. The heavier layer should be the lowest and all the layers should blend one into the other. Distinctive layering and patches of different cross section in different parts of the lawn should be rigorously avoided. In other words, the usual practice of dumping a load of clayey soil here and a load of sandy soil there, or of dumping a load of clay on top of a distinct sand, can not but fail to bring about a lack of uniformity in the subsoil of the lawn, resulting in different soil conditions establishing themselves in the course of time, giving patched lawns with poor and good sections or different grasses growing over the different soil conditions in the subsoil, even if the surface soil be uniform. The importance of the subsoil in the building of lawns can not be overestimated and the greatest care should be exercised where this is built up by filling in. This proper procedure of filling in for lawns costs little if any more than the haphazard way of dumping the material anywhere without due attention to texture and evenness of layering. In making the subsoil, the source of the material is, of course, not so vital a matter as with the surface soil, but the more nearly it is like a good surface soil the more desirable.

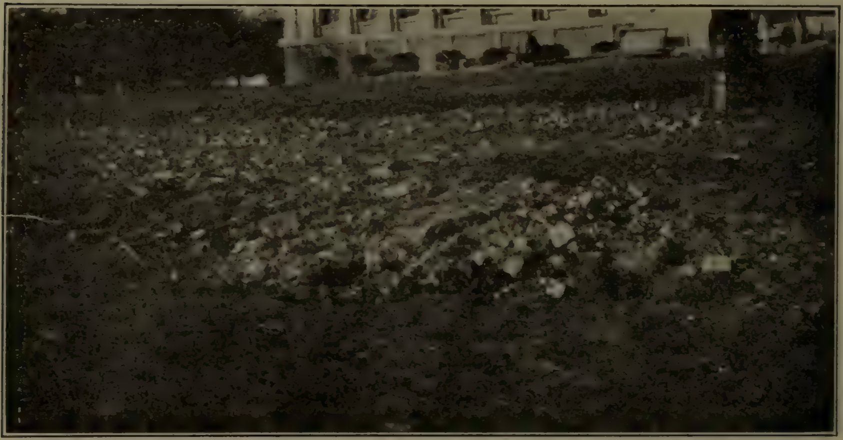


FIG. 5.—Faulty soil building on public grounds. The result of not specifying the nature of the subsoil to be hauled in by the contractors. While the illustration can not show the promiscuousness of the soil as to texture and kind, it does show the bricks and building débris which form no inconsiderable portion of the lawn.

HAULING IN OF PRODUCTIVE SURFACE SOIL.

The surface soil of a lawn must have been a good surface soil in its previous situation. It should be especially selected with due regard to the texture of the soil already in place as subsoil and especially in regard to its natural productiveness. The surface soil should blend with the subsoil; that is, its texture should not be markedly different from the subsoil and it should be lighter and loamier than the subsoil for the best results, unless the subsoil provided is sandy and loose. It is preferably obtained from a cultivated field, as this insures the best soil condition with the least danger of importing weed seeds. Inasmuch as the soil is to be put into permanent sod it is, moreover, better to have had other crops immediately preceding its establishment. It should never be taken from clay or sand banks, cuts or excavations, or similar situations, as no amount of doctoring with fertilizers, manures, or lime will make such soil immediately productive and suitable for a lawn without previous cultivation and the growing of cultivated crops. Only the very best soil obtainable should be used for such purposes, and it should be further improved as far as possible by the addition of organic manures, such as stable manure and bone phosphates and in some cases by moderate liming.

The surface soil should be spread over the graded subsoil uniformly. The depth of surface soil to be hauled upon the subsoil depends somewhat upon the nature and texture of the subsoil itself. If the latter is heavy and distinctly of a subsoil character, being hauled in from clay banks or moderately deep excavations, the surface loam should be made quite deep, at least 12 inches, but may in cases where the subsoil is itself good in texture and loamy in character be made much shallower, but not less than 6 inches. The object should always be to offer a loamy substratum for the roots to an appreciable depth so that they can penetrate deeply for their water supply.

SELECTION OF SOIL BEST SUITED FOR GRASS GROWING.

Lawns are not developed with equal success on all soils. This is due to the natural differences in soils as a result of their different formation, different texture, relation to subsoil, and to climatic conditions under which they occur and which also affect directly the grasses themselves. Some grasses are suitable for lawns under climatic and soil conditions under which other grasses perish, or at best do not reach that development necessary for the formation of a good turf. Attention has already been called to the influence of the texture of the soil on lawn building and the above statement emphasizes that thorough consideration be given to the soil region or province in which a lawn is to be established, or the soil series from which the lawn soil is to be obtained, especially where the soil is to be hauled from the country to the city for the establishing of good lawns, parks, or other public grounds.

The chief factors in this difference in soils has been brought about by the formations of soils from different geologic materials acted upon by different natural agencies, such as climate, humid, arid, semiarid; glaciers; wind; water—lake, ocean, and river. Due to such great differences in the soil-forming agencies upward of 700 individual soil types have been found by soil surveys in the United States. These fall naturally into larger groups known as soil series, and these, again, into still larger divisions known as soil provinces.

The question of what soil is best suited for the purpose of hauling in as a lawn soil is a very broad one and is naturally a local problem. In the following list are given the soil types, which, in the States mentioned, are prominent grass soils, and may, therefore, be suggestive of the kind of soil to be used in those localities where they occur. For a detailed description of these soil types, together with maps showing their location, the reader is referred to bulletins from the Bureau of Soils,[1] and the respective reports of the areas in the individual States as far as they have been surveyed.

Clays.

Hagerstown clay—Ala., Ky., Pa., Tenn., Va., W. Va.
Cecil clay—Ala., Ga., Md., N. C., Pa., S. C., Va.
Porters clay—N. C., Pa., S. C., Va., W. Va.
Houston clay—Ala., Kans., Miss., Tex.
Upshur clay—N. Y., Ohio, W. Va.
Vergennes clay—N. Y., Vt.
Vergennes black clay—N. Y., Vt.
Dunkirk clay—N. Y., Ohio.
Decatur clay—Tenn.

Clay loams.

Decatur clay loam—Ala., Tenn., Va.
Dunkirk clay loam—Mich., N. Y., Ohio.
Cecil clay loam—Ala., Ga., N. C.
Hudson clay loam—N. Y.
Wickham clay loam—Va.
Cumberland clay loam—Va.
Brooke clay loam—W. Va.

Silt loams.

Marshall silt loam — Ill., Ind., Iowa, Kans., Mo., Nebr., Wis.
Dekalb silt loam—Ala., Ind., Ky., Ohio, Pa., Tenn., Va., W. Va.
Memphis silt loam—Ill., Ky., La., Miss., Mo., Tenn.
Sassafras silt loam—Del., Md., N. J., Pa.
Norfolk silt loam—Ala., N. C., S. C., Va.
Lintonia silt loam—Ill., Ind., Ky., Miss.
Hagerstown silt loam—Pa., Tenn., Va.
Knox silt loam—Ill., Ind., Wis., Iowa, Ky., Mo., Nebr.
Volusia silt loam—Ind., N. Y., Ohio.
Wheeling silt loam—Ohio, W. Va.
Lansdale silt loam—Pa., Va.
Houston silt loam—Ala., Va.
Tyler silt loam—W. Va.
Penn silt loam—Pa.
Dutchess silt loam—N. Y.
Birdsboro silt loam—Pa.
Upshur silt loam—Va.
Oktibbeha silt loam—Miss.

Loams.

Hagerstown loam—Ala., Ky., Pa., Tenn., Va.
Chester loam—Md., Pa., Va., W. Va.
Dekalb loam—Ala., Ky., Pa., W. Va.
Penn loam—Md., N. J., Pa., Va.
Greenville loam—Ala., Fla., Ga., Miss.
Upshur loam—Ala., Pa.
Cumberland loam—Ky., Tenn., Va.
Sassafras loam—Md., N. Y.
Decatur loam—Ala., Tenn.
Vergennes loam—N. Y., Vt.
Holston loam—Ala., Tenn.
Volusia loam—N. Y., Ohio.
Talledega loam—N. C., Va.
Dover loam—N. Y.
Wickham loam—Va.
Fishkill loam—N. Y.

Fine sandy loams.

Norfolk fine sandy loam—Ala., Fla., Ga., La., Miss., N. C., S. C., Tex., Va.

---

[1] Use of Soils East of the Great Plains Region, by Milton Whitney, Bul. 78, Bureau of Soils, U. S. Department of Agriculture; Soil Surveys of the Bureau of Soils, U. S. Department of Agriculture, a list of which may be had on application to the department.

Orangeburg fine sandy loam—Ark., Ala., Fla., Ga., Miss., N. C., Okla., S. C., Tex.
Susquehanna fine sandy loam—Ala., Ga., La., Miss., Tex.
Dunkirk fine sandy loam—Ind., N. Y., Ohio, Wis.
Sassafras fine sandy loam—Md., N. J.
Wheeling fine sandy loam—Ohio, W. Va.
Cumberland fine sandy loam—Ala., Ky.
Greenville fine sandy loam—Ala., La.
Dover fine sandy loam—N. Y.

Sandy loams.

Hagerstown sandy loam—Ala., Pa., Tenn., Va., W. Va.
Cecil sandy loam—Ala., Ga., N. C., S. C., Va.
Carrington sandy loam — Ill., Kans., Minn., N. Dak., S. Dak.
Sassafras sandy loam—Del., Md., Va.
Collington sandy loam—Md., N. J.
Greenville sandy loam—Ala., Fla.
Superior sandy loam—Wis.
Tifton sandy loam—Ga.

THE IDEAL SOIL.

The ideal soil for grasses best suited for lawn making is one which is moderately moist and contains a considerable percentage of clay—a soil which is somewhat retentive of moisture, but never becomes excessively wet, and is inclined to be heavy and compact rather than light, loose, and sandy. A strong clay loam or a sandy loam underlaid by a clay subsoil is undoubtedly the nearest approach to an ideal soil for a lawn; it, therefore, should be the aim in establishing a lawn to approach as near as possible to one or the other of these types of soil. In many localities it will, however, be very difficult to produce by any artificial means at one's command a soil which will approach in texture either of the types recommended. Our efforts should, nevertheless, be directed to attaining as closely as possible these ideals.

GRADING SOILS FOR LAWNS.

Where a pure sand or a light sandy soil is the only foundation for the lawn, a top dressing of 2 or 3 inches of clay should be given and incorporated with the first 4 to 6 inches of the sand, and after this, if possible, the area should be used for the production of some green crop which gives an abundance of vegetable matter.[1] In latitudes south of Washington, D. C., cowpeas and soy beans, and in districts north of this red clover, vetches, and Canada peas are suitable for this type of soil improvement. These crops, if allowed to occupy the land until their maximum growth is attained and then plowed under, will act very beneficially upon the structure of the soil in making it more retentive of moisture, better able to hold fertilizers applied to it, and less liable to allow the greensward upon it to be killed out in times of drought.

Before definite preparations are made for the seed bed, the surface of the lawn should be reduced to the desired grade. In large areas a gently undulating or broken surface is much more pleasing than a uniformly graded surface. Such a surface also adapts itself better to plantations of trees and shrubs. For small grounds of less than an acre in extent the grading should be comparatively uniform and of the simplest possible character. The general statement made in regard to the contour of the surface is sufficient for guidance in grading such small areas.

---

[1] In addition to the green manure, a liberal dressing of well-rotted stable manure will add available plant food as well as increase the store of humus. A dressing of 20 two-horse wagonloads of such manure to the acre is not too much for quick returns and lasting effects.

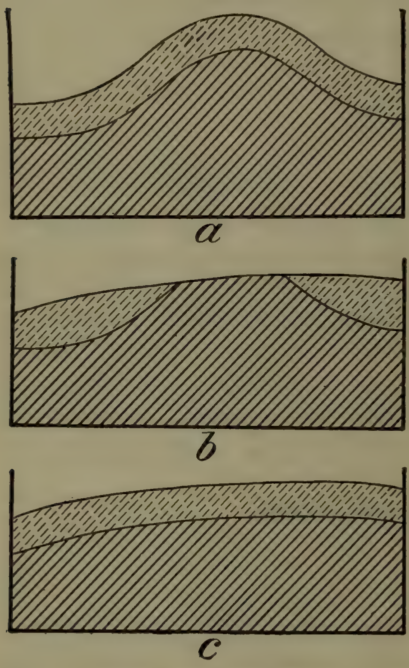


FIG. 6.—Proper and improper soil grading. *a*, Soil to be graded; *b*, improper grading, showing exposure of subsoil; *c*, proper grading.

In the establishing of lawns all grading should be done while the land is in the rough, just after the first breaking of the soil by plowing. When the surface soil is deep and the grading slight no special care is required, but where the soil is shallow or the regrading to be done considerable, care must be exercised so as not to make the surface soil so shallow as to prevent the proper growth of grass. Where the regrading is considerable, the proper procedure is to take up the surface soil and put it aside; then do all the necessary grading on the subsoil thus exposed. When the subsoil is thus brought to a grade, it should then be examined. Wherever an excavation has been made of sufficient depth to expose a subsoil different in appearance from that immediately below the top soil removed, its character should be determined. If hard and impervious to root growth it should be thoroughly plowed or otherwise loosened before replacing the top soil. An application of coarse manure would be helpful. If this plowing is not done, an allowance of at least 3 inches additional top soil should be made on these portions. After grading, the surface soil is uniformly spread over the land. This is a more economical procedure than to haul in fresh surface soil in after years to renovate the impoverished sections of the lawn where the subsoil was exposed and, furthermore, avoids the difficulty often found in procuring surface soil. In figure 6 is shown the right and wrong way of soil grading.

PREVENTING EROSION ON TERRACE BANKS.

As in grading, the exposure of subsoil must be avoided in making terraces on lawns. Erosion during heavy rainfall is an especial menace to terrace banks. For this reason a soil least subject to soil erosion should be used in their construction, especially in those cases where the terraces are artificially formed by the hauling in of soil. The surface soil should be one having a good structure and tilth, as a soil well granulated by thorough previous tillage, cultivation, and liming is less liable to erosion. The surface soil should blend well with the subsoil, and the latter should be one which will admit of rapid drainage, with no tendency to form hard or dry layers, impeding the downward movement of water. In stiff subsoils these drainage factors can be greatly helped by tile drainage, as on level land, thus insuring the percolation of water through soil and subsoil rather than over the surface of the terrace slope.

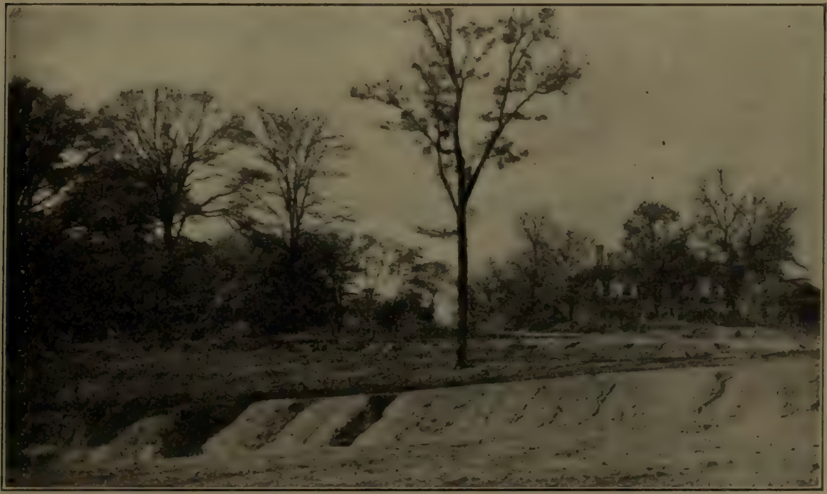


FIG. 7.—An eroded terrace bank. In terracing, proper attention must be paid to preventing erosion. Erosion during heavy rainfall is an especial menace to terraces. A soil least subject to erosion should be used in its construction and the surface soil should have a good structure or tilth, well granulated by thorough tillage and liming.

TILE DRAINS IN LAWN SOILS.

Proper drainage is a matter which is usually overlooked in laying out lawns, even where these are in large parks or estates. Land that is not naturally able to absorb any ordinary rain, forming pools or water-logged sections, or land which is naturally cold, is not well suited for lawn grasses until it has been underdrained. Underdrainage is so generally recognized as a prominent factor in improving unproductive lands for general agricultural purposes that it is surprising that it has not receivd more attention in the making of lawns and parks. Drainage has the effect of improving the fertility or productiveness of the lawn soil by carrying off excess of moisture, making it more open in structure, with improved aeration and bacterial activity, and making it warmer, an effect which is especially noticeable in the spring by the early awakening of the grass, and moreover tends to establish a much denser turf early in the growing season.

Tiles should be laid 3 to 5 feet deep and from 5 to 20 feet apart, depending upon the nature of the soil. No definite directions can be given in this regard. Much skill is required to dig the trenches accurately and to lay the tile properly. All tile should be laid several months before sowing the grass seed, so as to allow the ground to settle completely. The main tiles should be larger than the lateral tiles and a uniform grade be established toward the outlet. This outlet could be easily made in most parks by connecting the drainage system with the sewer pipes, and the same can be easily accomplished in the smallest lawn.

The effect of tree washings and tree roots on grass, and also of grass on trees, has been mentioned. Here, again, the use of tile offers the logical remedy. Tile should be laid on each side of the tree, preferably at the time when it is planted. This will serve to carry off the charged water running from the tree, and cause a better aeration and consequently destruction of débris from the tree. It will make the soil deeper and more productive for both the tree and grass, and by causing the tree roots to penetrate deeper into the soil prevent the interference of the roots of grass and tree with each other. In time the tree roots may get into the tile drains and prevent the free flow of ground waters. The object of laying the tile will have been largely attained before this happens. The tree roots may, however, be removed, as is done in tile-drained orchards, by means of a stiff wire brush on a cable. A further suggestion for removing the washings from trunks of trees, where this is found to be detrimental to grass, is to have a depression about the trunk or a slight embankment of sod, or even a collar of cement, around the base a foot or two from the trunk, and connecting the basin thus formed with the underdrainage system by means of an upright tile. The soil and subsoil should be kept separate in digging the trenches for the laying of tile, so that the surface soil can be again put on the top when the trench is filled.

PREPARATION OF THE SOIL.

Since the lawn is intended to be a permanent feature of the decoration of a place, its endurance or span of life is of utmost importance. In general, grass seeds are small and the surface seed bed for the reception of these seeds need not be more than 1 inch in depth; but since the grasses, as they become established, send out long lateral feeding roots, it is necessary that the soil area available for these plants should be as great as possible. This object can only be obtained by deep cultivation and thorough preparation of at least 8 or 10 inches of the surface soil. The soil to this depth should be made rich and put into an ideal condition for the development of plant roots. The mechanical operations of preparing the soil can be carried on by the use of the modern plow if the area is large enough, or by spading if the area is small. All weeds, roots, and other débris should be removed both before plowing is begun and as they appear in the process of the work. The seed bed should be thoroughly and frequently stirred. In short, the land is treated just as good farm or garden land should be treated for raising an especially valuable crop. If the soil is very rough after plowing, a disk harrow should first be used to cut up the clods. Where hardpan exists, or where the subsoil is otherwise hard, stiff, or refractory, the subsoil plow should be used. Subsoiling, which consists of stirring up the subsoil without bringing it to the surface, is often of great advantage where the surface soil is thin.

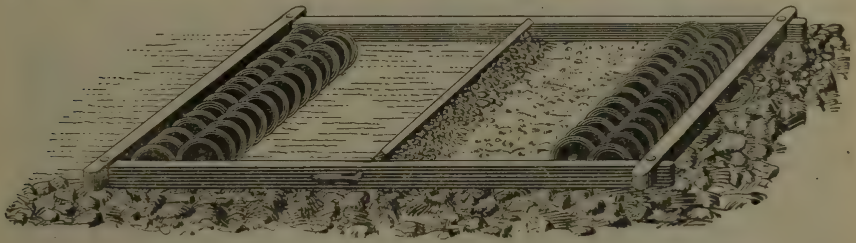


FIG. 8.—Harrow for smoothing and fining the soil preparatory to sowing the seed.

Cultivation should also have for its object the destruction of weeds which may interfere with the establishment of the lawn or which may be detrimental to it after it is once established. After the soil has been throughly plowed or spaded it should be carefully fined by harrowing or raking, after which it should be thoroughly compacted by the use of a lawn or field roller and the surface again loosened by the use of a steel-toothed rake or a specially constructed harrow, such as is shown in the accompanying illustration (fig. 8). This implement is frequently used by gardeners for the purpose of accomplishing on a large scale the results obtained by the use of a steel hand rake on small areas. This treatment will produce a suitable seed bed for the reception of the fine seeds of the grasses.

After the seed bed has been thoroughly and carefully prepared and the grass seed scattered in appropriate quantities, according to the kind used, the surface should be given a careful raking or rolling if the area is dry. If showers have been frequent, raking after the seed has been sown will suffice until after the grass has reached a height sufficient to be clipped by a lawn mower. Prior to clipping the grass with a lawn mower, if the ground was not rolled after seeding, a heavy lawn roller should be passed over the surface in order to make it as smooth as possible. After the grass has an opportunity to become erect it should then be clipped with the mower.

FIG. 9.—The cowpea used as a soil-improver in making lawns.

FERTILIZERS.

Since the lawn is a permanent feature, it is hardly possible to make the soil for the reception of the lawn too rich. Stable manure which has been thoroughly composted and rotted and which is as free as possible from detrimental weed seeds is undoubtedly the best material to use in producing the desired fertility of the soil. Forty to sixty loads of well-decomposed stable manure are not too much to use upon an acre of land designed for the greensward. Where such stable manure is not available the next best plan to follow is that previously suggested—the plowing under of green crops, such as clovers, cowpeas, soy beans, and similar plants. The land should then receive an application of about 1,000 pounds of lime to the acre, and at the time of preparing the seed bed 500 to 1,000 pounds of fine-ground bone, together with 300 to 500 pounds of a high-grade fertilizer upon each acre. The fertilizer may contain 3 per cent nitrogen, 6 to 8 per cent phosphoric acid, and about 8 per cent potash.

The fertilizer improvement above suggested is to be made on what is already a fair soil and one which has been a surface soil for some years. If the soil is texturally good, but is in bad physical condition otherwise, or is a raw soil—that is, one which has been a subsoil in its former position—then it is necessary first to change this into a surface soil with good tilth and structure by treating it with manure, fertilizers, and lime and growing cultivated crops on it for a year or two. A soil which will not grow a good crop of corn or potatoes will not grow a good crop of lawn grass. The cultivation of the ground during the growth of the crop will gradually make a soil out of the raw subsoil, and this should be continued until it is sufficiently good to grow a good potato or corn crop. Crops to be plowed under as green manure, such as cowpeas or rye, are desirable. These precautions will insure a good soil for the growth of a permanent greensward and will pay for all the labor expended, especially as without these precautions only an indifferent lawn can be obtained on such soils. When the soil is ready for the lawn give it its final treatment with lime and fertilizers and seed to grass.

GRASSES ADAPTED TO LAWN MAKING.

It is evident that not all grasses are adapted to lawn making. Only such kinds as are capable of making a close turf are ideal for lawns. Most grasses which have creeping root stocks, short joints, and produce long, narrow leaves in abundance about the crown of the plant adapt themselves well to lawn making. Besides this, a desirable lawn grass possesses a pleasing color, which does not change decidedly from season to season, is drought resistant, responds quickly to a change of conditions from winter to spring, and bears repeated clippings with a lawn mower. It will be noted that the requirements of these grasses are exceedingly exacting, and it is not surprising to find the list of such grasses a comparatively short and meager one.

In those localities where ideal soil and climatic conditions are not present a mixture of grasses is better adapted to lawn making than a single variety. Under conditions where the soil and climate are congenial for the development of grasses a more perfect lawn can be made by using a single species than by the use of a mixture. In general, because of varied conditions of shade and moisture existing upon a lawn as the result of trees, shrubs, and architectural objects, mixtures are more desirable than pure grasses. The different degrees of shade and moisture maintained in the soil which result from the presence of trees, shrubs, and buildings afford a variety of conditions under which a single species would not produce a uniform lawn. These obstructions to the sunlight produce lights and shades in different parts of the lawn, so that any difference which may exist in the color of the various grasses in a lawn mixture is not so obtrusive as it would be were different portions of the area made up of grasses of different hues. Even if there is variation in the tints of the green in the different grasses used in a lawn mixture, this will not become objectionable unless the lawn becomes patched and made up of one variety in one place and a different variety in another.

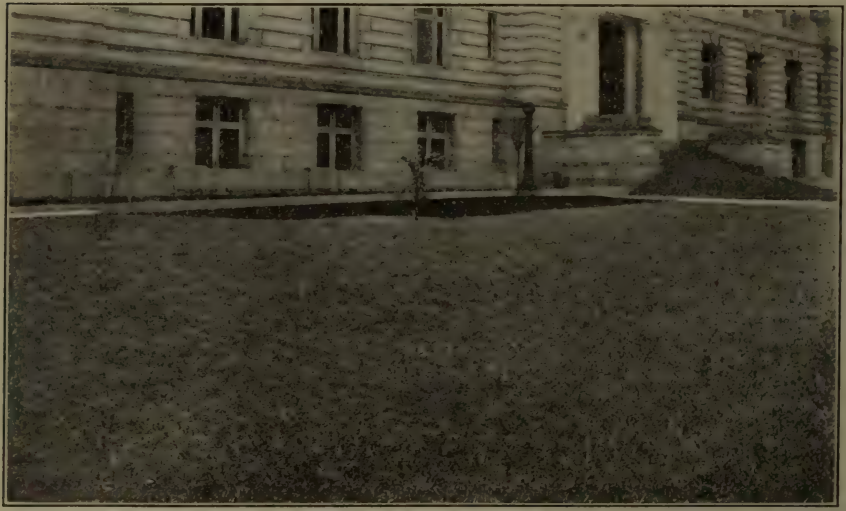


FIG. 10.—A good blue-grass lawn on soil properly filled in and prepared.

FOR SUNNY AREAS.

Kentucky bluegrass is undoubtedly the great American lawn grass. It thrives best in a comparatively retentive, strong soil, where there is an abundance but not an excessive amount of moisture. It is adapted to all the Atlantic coast region north of Washington; to the clay lands and lands with clay subsoil in and near the Allegheny region south to Georgia and Alabama; to the Mississippi Valley south as far as Mississippi and including the Ozark Mountains in Arkansas and west to the Missouri River; to the irrigated sections of the Rocky Mountains; to both the humid and irrigated lands of the Pacific coast south to Los Angeles. Its chief companion is redtop through practically all these regions, especially on the lighter soils. These two grasses make up from one-half to two-thirds of most of the leading grass-seed mixtures sold in the regions mentioned. Most of the largest makers of lawns use 2 parts by weight of Kentucky bluegrass to 1 of redtop. The soil that does not suit one of these grasses is likely to be suitable for the other, so that a good lawn will result, except perhaps on the lightest lands. The nurse crop for this combination is white clover. Rhode Island bent and creeping bent have the same ability to make a compact, thick sward as does Kentucky bluegrass and with the redtop thrive on lands too light for success with the Kentucky bluegrass. Under certain conditions redtop and the bent grasses are able to make a softer, although not a more permanent, turf than does the bluegrass.

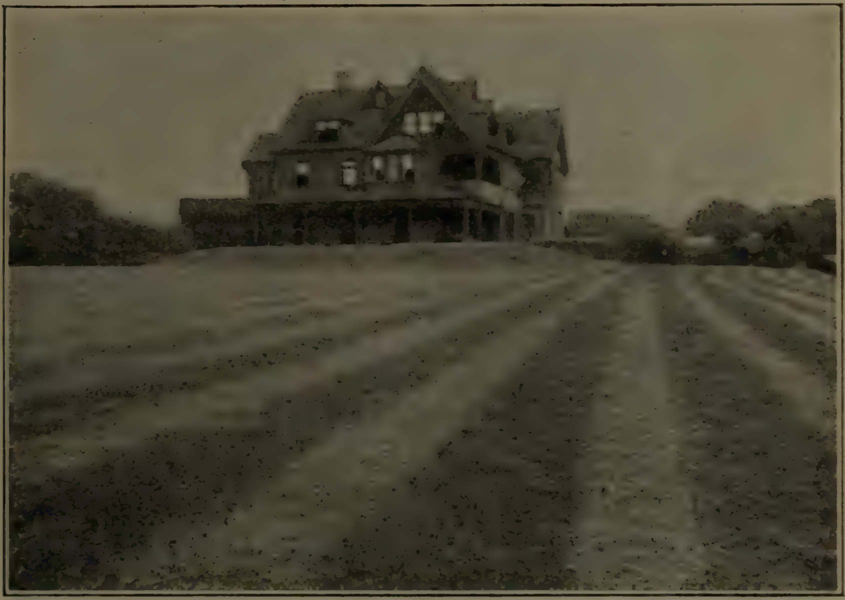


FIG. 11.—A typical bluegrass and white-clover lawn. The recent use of the mower has left a striped effect upon the greensward.

Other good grasses as part of a general mixture or for special conditions are Canada bluegrass, the fescue grasses, wood meadow grass, and sweet vernal grass. White clover makes a beautiful lawn quickly, but is soon crowded out in the presence of a good stand of the best lawn grasses under the close cutting which a well-kept lawn requires. It answers a good purpose in protecting the young grasses the first year. This is especially necessary with bluegrass, which is weak and tender until the second year.

Seashore lawns are each year becoming of more and more interest because of the great number of residences which are being established along the Atlantic coast from Maine southward. While there are known to botanists a number of forms of common grasses besides bluegrass and redtop which are maritime, none of these have been taken up by commercial seedsmen and produced in sufficient quantities to be available for lawn making in these regions. Persons wishing to establish lawns under these circumstances must therefore depend largely upon the same grasses that are used for the making of lawns farther from the coast—Canada bluegrass, Rhode Island bent grass, redtop, white clover, the fescue grasses, and especially creeping bent. Under coast conditions it is advisable to use even more liberal mixtures of these grasses than in sections where lawn making is thoroughly understood and where a single species may be used with certainty in establishing a satisfactory lawn. If the seed can be obtained, the seacoast bent grass is a valuable addition to the above list.

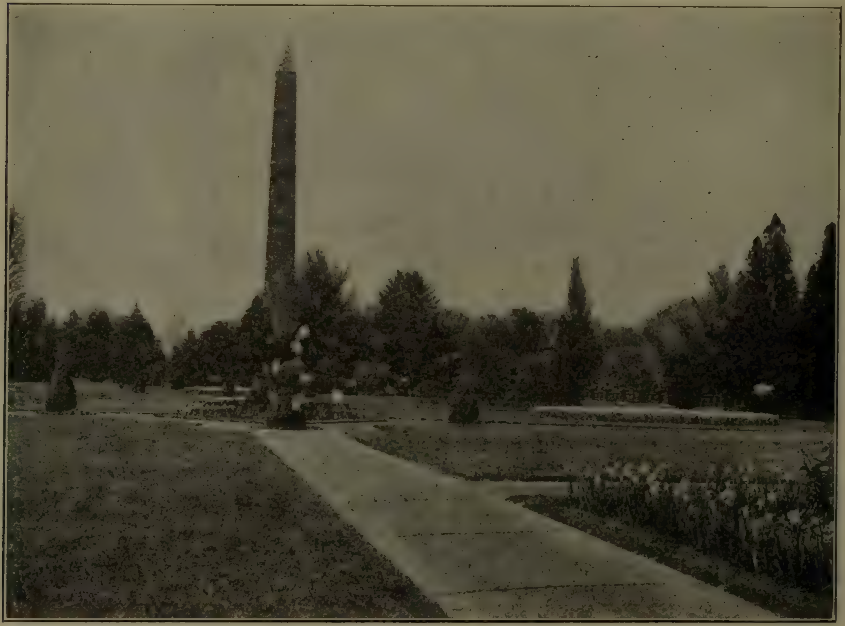


FIG. 12.—An excellent mixed-grass lawn on the Agricultural Department grounds, Washington, D. C.

From the city of Washington southward, particularly upon the sandy soils of the Atlantic coastal plain and along the Gulf, Bermuda grass is the main dependence for lawn making. Near the borders of the bluegrass region this may be in combination with bluegrass or with bluegrass and white clover. The Bermuda grass will grow in the hot sunny weather of summer, which burns the bluegrass. The frosts will brown Bermuda grass, but bluegrass keeps the lawn green through the winter. Where the bluegrass will not thrive, Italian rye grass is sown each fall in the Bermuda grass. It gives a green turf during the winter and dies in the spring. It is suggested that white clover be tried in this same way from Norfolk southward. To accomplish this, about October 1 clean off the Bermuda grass as thoroughly as possible with a scuffle hoe, then loosen the top 2 inches thoroughly for a fine seed bed, but do not remove the roots of the Bermuda grass. On this seed bed sow either white clover at the rate of 25 or 30 pounds per acre or Italian rye grass at the rate of 2 bushels per acre and roll lightly: This should give a satisfactory green cover during the season the Bermuda grass is unsatisfactory. As hot weather approaches the Bermuda grass will crowd out the other grass. This seeding will have to be repeated annually in order to have the lawn green during winter. Where it will thrive, the bluegrass-Bermuda turf will probably be more satisfactory.

This mixture of the two grasses must be practically uniform throughout. Lawns in which Bermuda grass has gained an entrance and killed out bluegrass in places present a very unsightly appearance after severe frosts have occurred in the autumn, the bluegrass remaining bright and green while the Bermuda grass, after having been frosted, turns light brown, thus presenting a very spotted and unattractive appearance (see fig. 12). Under these conditions the Bermuda grass, which in general may be considered a good and desirable lawn grass, becomes a weed. Another weedy grass which is likely to produce a similar effect upon lawns in which the grasses have "run-out" is crab grass, as shown in figure 19.

When the confines of Florida have been reached, however, the conditions are somewhat different and the warmer climate and the greater humidity allow different species to endure, as, for instance, the St. Augustine grass, which has a coarse and very upright leaf, although it has a creeping rootstock. This grass is of special value in Florida, as it remains in a green condition practically throughout the whole year.

Korean lawn grass is a maritime grass from Asia and Australia, which is proving of value along the seacoast from Charleston southward. It thrives well in the latitude of Washington, but the leaves are not hardy and assume a light straw color in winter. It will, however, undoubtedly be a decided acquisition for lawns near the seashore in latitudes south of Washington. In Texas the mesquite, a native grass, is ranked with Bermuda grass as a desirable lawn grass.

For certain areas west of the Mississippi River, where the grasses already mentioned do not thrive, it has been suggested that a native grass known as buffalo grass, which has the characteristics of a good lawn grass, that is, creeping stems and short, upright leaf shoots, be employed for lawn purposes. This grass has ability to withstand drought, and to establish and maintain itself under adverse climatic conditions. Since buffalo grass is indigenous to the region and possesses so many qualities which are of importance in a lawn grass it is worthy of special consideration in this area. It has the one drawback that the seed is not now available in commercial quantities. On the sandy lands of the Pacific coast from San Francisco south the rye grasses and Bermuda grass are apt to prove the most satisfactory.

There are a few grasses which in themselves are well suited to lawn making, but which because of their habits of growth are not well adapted to use in lawn mixtures. Italian rye grass is a notable example of this type of plant. It is in itself capable of making a fairly good lawn, but because of its more rampant growth and broad leaf blades, which possess a shiny appearance, it does not blend well with other grasses on the lawn—such as redtop, bluegrass, and white clover. It grows more rapidly than do these species, and always appears as an obstrusive companion on the lawn. It is, therefore, not advised as an important or desirable feature in a lawn mixture.

FIG. 13.—A patch of Bermuda grass in a bluegrass lawn in winter.

Perennial rye grass is sometimes recommended for lawns, but in lesser degree has the same objection as the Italian rye grass. It is often used in mixtures for quick results. It usually dies out in two or three years, but always gives a lawn a weedy appearance.

FOR SHADY PLACES.

Lawn grasses do not thrive equally well in sun and shade. In dense shade it is usually impossible to maintain a turf. This difficulty is especially pronounced in small city yards and in the grass strips under unthinned Norway maple trees on a city street. There are three factors that may contribute to this trouble: (1) Shade; (2) local drought caused by the twofold action of the tree in keeping rain from the ground under it by the denseness of its foliage, and by the absorption of moisture and plant food by its roots; (3) a possible poisonous action of the tree on the soil as already mentioned. Probably the second factor is the most important as dense foliaged shallow rooted trees are the most difficult under which to keep grass. However, in a drought when large open areas of lawns are brown and parched, it is often noticeable that the grass under the limbs of the surrounding trees has the richest color and keeps growing slowly. The Rhode Island bent, creeping bent, and Canadian bluegrass do well in shade. The latter is a grass that is persistent in gravelly lands and under considerable traffic. It does not make as fine a turf as the other shade grasses, it being rather wiry. The red fescue and the sheep fescue are also desirable shade grasses. Unless the sheep fescue is crowded, it is apt to grow in clumps or hummocks. For this reason it is best used in mixtures and where the seeding is heavy. Orchard grass is a coarse grass that also grows in hummocks, but where crowded with some other grass it will often enable one to get a turf where otherwise it is impossible. It should only be used when the better grasses are known not to succeed. In attempting to seed in shade it is advisable to use as many promising varieties as possible in the hope of finding those that will respond to the particular conditions. On broad areas in sun it is desirable to use just as few varieties as possible. For the small home lot it would be better to use a mixture for there conditions of both sun and shade have to be met.

By a proper selection of the kinds of grasses sod may often be maintained where the conditions are quite severe. Kentucky bluegrass stands shade well, especially where not subjected to severe tramping, and is the basis of shade mixtures as offered by seedsmen. In the South it does better in the shade than in the open. The wood meadow grass is the very best of shade grasses for the regions where Kentucky bluegrass and redtop flourish. Formerly this grass was added in large quantities to the ordinary grass mixture to make it a "shady nook" mixture. Its excessively high price in recent years has largely prohibited its use except in a small way.

Along the Gulf coast the grass known as carpet grass is well adapted to shade and is a strong competitor of Bermuda grass for all lawn purposes. It has a habit of growth very similar to that of Bermuda grass, and it is possible that when it shall have been given a thorough test its region of adaptability will be coextensive with that of Bermuda grass. Under some conditions it thrives and maintains itself to even a greater extent than does the Bermuda grass. It also has another advantage in that in certain localities it produces seed which with little care may be gathered and may become a commercial commodity. Whether or not carpet grass will carry its seeding habits to its northern limits remains to be determined. It is readily propagated from turf, like Bermuda grass, and can be easily established upon a lawn, but it is not so difficult to eradicate if that should be necessary.

Another good grass for shade on clay lands in the moist regions of the extreme South is the large water grass, while the knot grass is good on sand under the same conditions.

So many of the fescue and bent grasses being indigenous to or naturalized in the Rocky Mountains and the neighboring plains, it seems that the lawn grasses of the future for these regions must be found among these plants.

On the Pacific coast south of San Francisco the rye grasses are the most promising for use on sand in shade.

FOR TERRACES AND TERRACE BANKS.

Terrace banks are an abomination that should be avoided if possible. They have their place in landscape design, but their use has been abused. The influence of a style of gardening in vogue nearly two generations ago, and the practice of railroad engineers who treat their station grounds with the same ideals as their right of way, still have their effect upon the ordinary contractors and gardeners who are responsible for most of the work on small places. Many a city lot has been spoiled by grading it as in *a* and *b* of figure 14, when it could more cheaply have been given the pretty contours of *c* in the same figure.

If the style of the place has demanded a terrace it is fair to assume there are ample funds to provide ideal conditions for the maintenance of the lawn on this area; soil of ideal texture and fertility, and proper means of irrigation, so the only thing left is to select the one or two kinds of grasses adapted to the climate, Kentucky bluegrass for nine-tenths of the United States, carpet grass, St. Augustine grass, or possibly Bermuda grass with Kentucky bluegrass in the remaining tenth. There are legitimate terrace banks and other legitimate banks in landscape work that must be treated besides the illegitimate ones mentioned. Wherever possible these should be covered with creeping shrubs, woody vines, or trailing plants. Grass should be used only where harmony absolutely demands it. The objections to a grass bank are two: First, the difficulty of maintaining a close turf on a steep incline; second, the great difficulty and consequently additional cost in keeping it properly trimmed. Where grass is chosen for the covering sodding is usually the most satisfactory. For the bluegrass regions the Kentucky bluegrass is best on clay soils. On lighter soils use Canadian bluegrass; Rhode Island and creeping bent; sheep, red, and hard fescues. As a last resort in difficult places use orchard grass with plenty of other grasses. In any case, keep reseeding constantly and heavily. From Washington, D. C., to Texas, outside of the bluegrass region, use Bermuda grass. In California from San Francisco southward use Pacific rye grass, or Bermuda grass on the lighter soils.

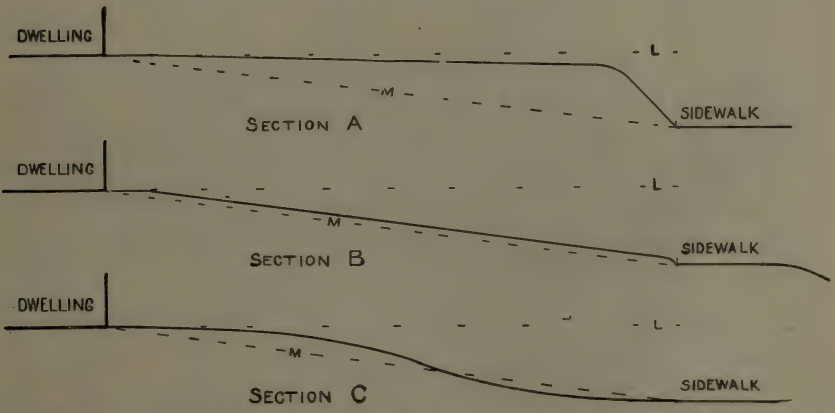


FIG. 14.—Cross sections of bad and good grading of small front yards. *L* indicates the level of the house foundation, and *M* a straight line from the top of the house foundation to the sidewalk level. *Section A:* Bad, with the rare exception of where a strictly formal treatment is admissible. *Section B:* Bad. *Section C:* Good. This ogee curve may be short or long to accommodate the difference in height between the dwelling and sidewalk, and the distance between them.

OTHER GROUND COVERS.

On banks too steep for walking over readily upright shrubs may often be planted appropriately. If the banks are liable to wash, such drooping shrubs as drooping golden bell or matrimony vine can be used to advantage, their drooping stems running along the ground and rooting at frequent intervals and holding enough leaves to prevent wash. Such bushes will often form a mass of foliage 6 feet high. Where lower forms are essential, Japanese honeysuckle, Virginia creeper, or English ivy may be used, or the more herbaceous plants like moneywort, creeping Jenny, and myrtle. These plants are as easy to establish on a bank as turf. They do not require weekly clipping. After once established they only require a little time occasionally to remove a bit of grass or a weed or the training of a stray branch. They make a more perfect cover than grass, and maintain themselves better. The Japanese honeysuckle may become a nuisance by climbing over any bushes, fences, or walks within reach. Its seed is easily carried by birds, it is already naturalized over a large part of the Eastern States. The Virginia creeper is not quite so persistent but is native over the whole country. The English ivy is not hardy in the northern sections. In the extreme South the variety Hibernica should be used. For ground cover in shade where it is difficult to grow grass, the English ivy, moneywort, myrtle, and a Japanese form of the mountain spurge are excellent.

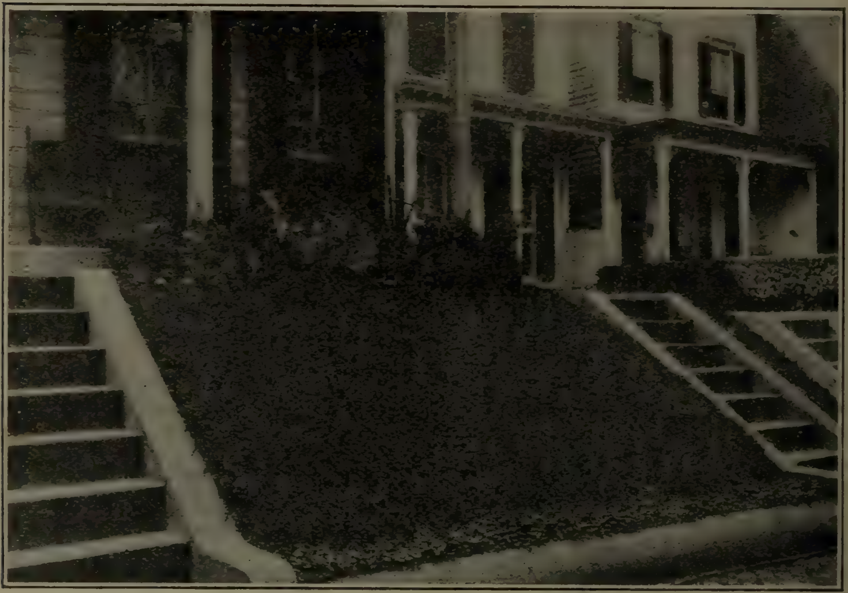


FIG. 15.—Steep bank facing north; partially shaded by trees; creeping jenny at the foot of the slope, moneywort on the face of it, and flowers at the top. A neat lawn can not be maintained on a bank like this, and an ordinary one only with great care.

SEED.

In procuring seed for establishing a lawn, too great care can not be exercised. Pure seed, of high germination, is of great importance in securing a good stand of grass. Pure seed is the keynote to a clean lawn, provided the work of preparing the land has been efficiently done. Thorough preparation involves not merely the mechanical treatment of the soil to reduce it to a proper seed bed, but the use of weed-free manure and the adoption of a course of treatment previous to preparing for the lawn which shall serve to eradicate weeds. Such preparation, coupled with pure seed, should give a satisfactory stand of grass which shall need only the usual care necessary to maintain a lawn after it is once established. Too much can not be said in favor of securing pure seed, and, if possible, specially selected seed. This is of course of considerable importance with light seeds like bluegrass, redtop, and seeds of the bent grasses. In the case of bluegrass, select seed weighs about 22 pounds to the bushel, while the ordinary grade of bluegrass, although it may be called pure, averages about 12 pounds to the bushel.

Select or recleaned bluegrass is therefore the most economical to buy, although the original cost is considerably more than that of the common article. The stand of grass resulting from the use of recleaned selected seed is much more uniform than when seed containing a great number of hulls and light seeds is employed. The same remarks hold with the bent grasses and even with white clover, although the market at the present time does not offer as much opportunity for selection with this last-named seed as with the bluegrass. With redtop, however, there is an even greater opportunity of choice than with bluegrass, it ranging from pure seed, from which most of the hulls and all of the chaff have been removed, to seed containing hulls, chaff, and foreign matter. Buyers in small quantities should purchase the extra fancy recleaned seed that contains no chaff and comparatively few unhulled seeds. Buyers of large quantities should familiarize themselves with the different grades, as often it is true

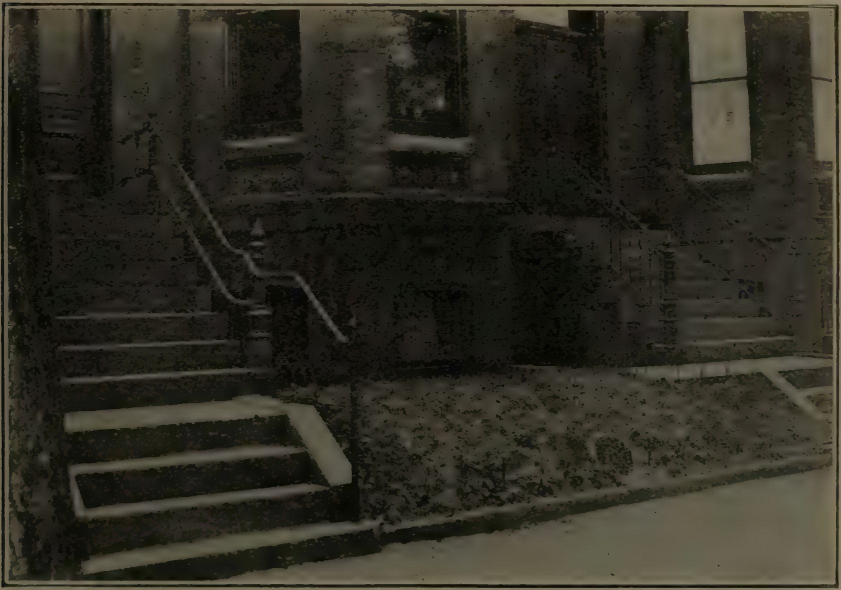


FIG. 16.—A grass bank better than the average on slopes, especially under city conditions.

economy to purchase a good sample of unhulled redtop rather than the hulled. There is no lawn grass seed so difficult to pass upon intelligently. Fancy recleaned seed should weigh 45 pounds to the bushel. Chaff redtop will weigh as low as 10 pounds. It is seldom policy to buy seed weighing less than 16 or 18 pounds to the bushel.

The quantity of seed to be used upon a lawn is of decided importance. It is better to use an excessive amount of seed and allow natural selection to eliminate the weak specimens rather than to seed sparsely with the hope that the natural habits of the plants will be sufficient to enable them to take possession of the entire area. A thick stand of plants of the desired species gives little opportunity for the development of weeds, while a thin stand of the same species offers a place for the growth of weeds, which may become determined competitors for the possession of the ground, thus subjecting the gardener to the necessity of eliminating the weeds or of reestablishing the lawn. Heavy seeding of grass is therefore a very important matter in the establishment of lawns.

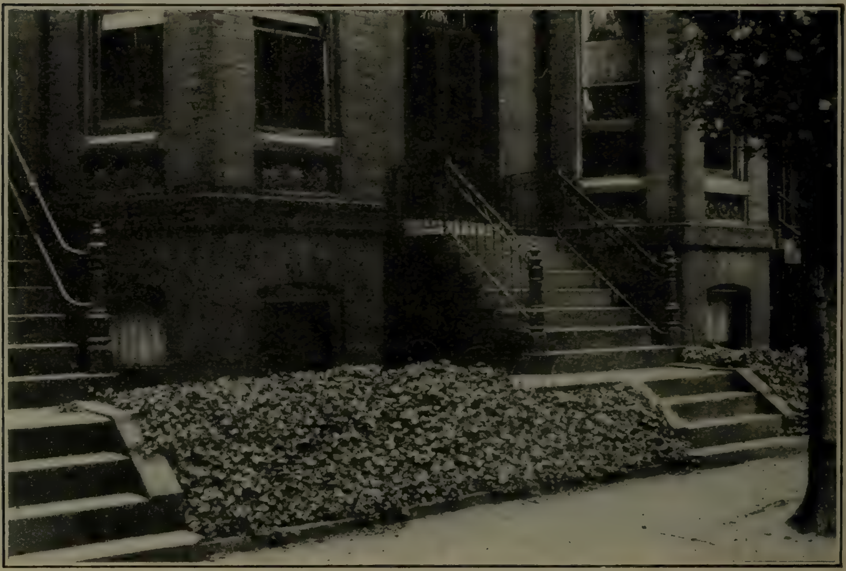


FIG. 17.—A bank of English ivy in Washington, D. C., only four doors from the bank shown in figure 16, in front of the same row of houses.

Bluegrass, bent grass, and the fescues, if used in combination, should be sown at the rate of 3 to 5 bushels of seed to the acre. Bluegrass, if used alone, should not be used at a rate less than 50 pounds to the acre, while 70 pounds is better. White clover, if added to the collection of the above-named sorts, should be used at the rate of one peck to the acre. Upon sandy or gravelly lands and in spring seeding white clover is an important factor, because it germinates quickly and covers the ground, affording protection and presenting an attractive appearance earlier than is possible by the use of other grasses. White clover, too, is able to reestablish itself very quickly after periods of severe drought, and until the bluegrass, redtop, bent grass, and fescues become thoroughly established the white clover will usually be in the ascendant. As the turf-forming habits of the other grasses become more marked, however, the white clover will gradually disappear and give place to the other more permanent grasses.

ESTABLISHING A LAWN.

The successful establishment of a lawn depends upon the careful preparation and the proper fertilization of the land and the selection and planting of appropriate grasses. In those localities where a lawn can be established by the use of seeds the preparation of the seed bed and the selection and sowing of the seeds are exceedingly important questions. General directions for the preparation of the soil have already been suggested. In order that seeds of suitable character may be secured, it is desirable in the first place to determine the varieties which succeed best in the locality.

The largest users of lawn grass seed in the Mississippi Valley and northeastwardly to the Atlantic from Washington northward use Kentucky bluegrass and redtop, either equal parts, by weight, or more often two parts bluegrass and one part redtop, sowing in either case 70 pounds to the acre, and in most cases sowing also 6 quarts of white clover to the acre. In the irrigated sections of the country bluegrass alone or bluegrass and white clover seem to be the preference. The best lawn mixtures on the market are composed of approximately one-third Kentucky bluegrass, almost as much redtop, with Rhode Island bent, creeping bent, sheep fescue, red fescue, and a little sweet vernal grass to give the lawn a pleasant odor when cut. Wood meadow grass was formerly added to this in large quantities to make it a mixture for shady places, but on account of its high price the fescue grasses are now more largely used. These mixtures are admirably adapted for ordinary conditions of light and shade, dry and wet, of the average lawn.

Bermuda grass seed is not commercially grown in the United States, and because of the expense of the Australian product the only economical means of propagating this grass is by division of the rootstocks.

In those sections where seed sowing is depended upon a very finely compacted upper stratum of soil is essential. In order to secure a uniform distribution of the seed, the seeding should be done in two directions. The seed should be divided into two lots, one of the lots being scattered in one direction across the land and the other scattered at right angles to the first. This is done in order to obliterate as far as possible balks and streaks in scattering the seed. It is best to divide the land into strips 6 feet wide, stretching strings in the case of a small lawn, or by a light, easily devised horse marker for large areas. Then a man should be given each strip to sow by bending his back and scattering the seed evenly through his fingers, held close to the ground. Grass seed can not be satisfactorily sown by the method used for broadcasting grain or clover seed.

Since grass seed is very small, every precaution should be taken to bring the seed in close contact with the soil. Nature does this in an ideal way by gentle showers. It is therefore desirable upon small areas to sow the seed immediately before a shower. If the shower is a gentle one of some duration, it is more desirable than a violent rain. Torrential rains, if the surface of the lawn is sloping, usually cause damage, which must be repaired.

After the lawn has been established and it has gone into "winter quarters" it is well to give the young grass a mulch of well-decomposed stable manure, which shall not be heavy enough to disfigure or mar the lawn, but should be so fine and well decomposed that it will be carried beneath the surface of the grass by the rains and snows of the winter, leaving very little rough or unsightly matter to be raked off in the spring. If this is not desirable, after the greensward has passed through the first winter it should be treated to a top dressing of fine-ground bone at the rate of 1,000 pounds to the acre.

In the case of establishing lawns, if the grasses which grow from seed can not be used, it is necessary to resort to one or the other of the following methods: (1) The establishment of the lawn by the use of small tufts of grass or pieces of turf planted at intervals sufficiently close to allow the natural spreading of the plant to soon take possession of the entire area or (2) covering the entire area with turf. In the Southern States, where the Bermuda and St. Augustine grasses are depended upon for lawn purposes, the common practice is to cut the turf up into small fragments about 2 inches square, or to take small tufts of roots and stalks of the grass, as much as can be easily grasped in the hand, and insert them in the soil at intervals of about 10 or 12 inches in each direction. When not planted in checkrows in this fashion the roots are usually set in rows or drills 12 or 15 inches apart in one direction with the tufts of grass 6 to 10 inches apart in the row. Slight cultivation is then practiced between these rows to keep down weeds until the rootstocks of the plant have gained possession of the entire area.

SODDING.

Upon banks where grass can not be readily established from seed or by planting, as before indicated, the sod or turf is usually removed from some area where suitable grass is well established and used to cover the entire surface. It carries with it all the difficulties of sod laying, greater expense, introduction of weeds and undesirable grasses, and other undesirable features. Only sod grown for such purposes is safe to use.

Where such sod is procurable, its use to quickly cover terrace banks is advisable, even though more expensive than seeding. On terrace banks the first cost of sodding is much greater than seeding, but this additional expense is perhaps no greater than that incurred by repairing a partially eroded terrace bank a second or even a third time. The laying of sod does not mean, however, that the condition of the soil on the terrace slope can be neglected because so quickly rendered invisible.

A common method employed in this work is to cut the sod into pieces a foot square and about 2 or 2½ inches thick. This answers well upon small areas if the sod is cut to a uniform thickness and the surface of the ground is made very smooth; otherwise there is more or less difficulty in getting the squares of sod adjusted evenly so as to produce a smooth surface. Considerable ramming or pounding is necessary in order to establish the desired smoothness, unless great care is exercised in cutting the turf to a uniform thickness and in providing a smooth surface to lay it upon. In order to overcome this difficulty when extensive sodding operations are to be undertaken, a device which in its action is similar to an ordinary carpenter's plane is used. Such an implement is shown in the accompanying illustration. (Fig. 18.) This device is used to cut long strips of turf. After the strips of turf have been cut by horsepower with the implement illustrated they are rolled into rolls of convenient size for handling and the sodding is accomplished by unrolling the turf over the area to be grassed. After placing the sod in position it is thoroughly rammed down with a heavy wooden maul or pressed down with a lawn roller in order to produce a uniform and smooth surface.

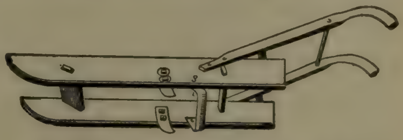


FIG. 18.—Implement used for cutting sod.

WHEN TO PLANT A LAWN.

There is a legitimate difference of opinion in regard to the season at which it is best to plant a lawn. There are those who are very successful in lawn making who depend almost entirely upon fall planting, and there are others who are equally successful who advocate the practice of spring planting. Both of these systems are successful, and the prospective lawn maker can use the method which best suits his convenience. If the seeding is to be done in the autumn, the latter part of August or the month of September is the best period for accomplishing the work in latitudes between Washington and Boston. In the southern portion of this zone the work may be deferred until October. The preparation of the land for this work should be thorough. The seed bed should be made very fine and every precaution taken to give ideal conditions for the germination of the seed. If possible the seeding should be done at a time when the fall rains are most abundant; but, as frequently happens, in the eastern part of the United States within the zone mentioned there is a more or less protracted drought during the fall. It is not advisable to sow the grass seed during a dry period, unless there are at hand artificial means for watering which can be used to force rapid germination and growth.

Fall planting has the advantage of allowing a number of weeds in the area to germinate and be killed by the frosts and freezes of the winter. If the grass attains a height of 2½ or 3 inches before winter there is little danger of loss from severe weather. In localities where the surface of the earth is not protected during winter by a snow cover and the ground is likely to freeze and thaw repeatedly it is not advisable to attempt to establish a lawn in the late autumn.

The drawback to spring planting is that work must frequently be delayed longer than is desirable because of unfavorable soil conditions, particularly upon heavy and retentive soils. Young plants suffer severely from heat and drought if they have not had an opportunity to grow and form considerable root before the hot period comes on. Weeds which come in advance of the spring planting of the lawn can be overcome in a measure by giving the land partial preparation in the autumn and allowing the first crop of weed seed to germinate before cultivation and the preparation of the seed bed is completed, using this cultivation to destroy the first crop of weeds as well as to prepare the seed bed for the lawn. The later weeds can be held in check by frequent clippings with the mower.

As one goes south from Washington the time of lawn making becomes later in the fall and earlier in the spring, the controlling factors being moisture with sufficient high temperature to start the seed. Where Kentucky bluegrass and Bermuda grass are to be grown together it is desirable to start the lawn rather early in the fall, so as to enable the bluegrass to get as much start of the Bermuda grass as possible. Young Bermuda grass sets would only be held in check by the cold weather of winter, while newly started Kentucky bluegrass plants would be killed by the severe, hot, dry weather if started in the spring.

MAINTENANCE OF A LAWN.

All operations connected with the maintenance of a greensward are directed toward securing a uniform sod or turf over the entire extent of the lawn. In order to secure this the plants which constitute the lawn should be kept in a luxuriant, vegetative condition and never allowed to go to seed. There is no operation connected with plant life which is so trying upon the vitality as the production of seed. In order to keep a close, even surface over the area it is necessary to use a mower frequently, but in using the mower the clipping should not be done close enough to deprive the plants of sufficient leaf area to carry on their normal functions; that is to say, as a general rule the lawn mower should be set high rather than low. Upon newly established lawns the operation of clipping should not be delayed until the grass is too high. As soon as a mower with the blade 2 inches high will cut the leaves the mower should be passed over the surface. By repeating this at close intervals during the growing season a better and more uniform stand of grass will be secured.

It is a mistake to allow a lawn to go in an unkempt condition during the first months of its existence. It should from the begining be subjected to the same treatment which is to be carried on later in its life. It is not advisable to clip the lawn frequently during periods of drought, but even during these periods it is not well to allow the plants to produce seed stalks. The general plan of keeping a lawn clipped to a height of 2 inches is a very safe one to follow. The clipping should be sufficiently frequent to prevent the necessity of raking off. If the soil is moist, very rich, and the growth luxuriant, it will be necessary to catch some of the clippings in a carrier on the machine for a few of the spring cuttings, but on comparatively poor soils the clippings will not be detrimental if cut frequently enough. Before growth has advanced to any considerable extent each spring, the lawn, as soon as it is comparatively dry, should be gone over with a heavy lawn roller, so as to embed firmly any of the grass roots which may have been loosened by the frosts and to reduce the surface to a uniform condition.

WEEDS.

A weed is "a plant out of place." It thus happens that grass is sometimes the worst weed of the lawn. Desirable grasses may be scattered in patches through an otherwise well-mixed lawn and produce as bad an appearance as some other weed. Figure 13 shows a spot of Bermuda grass in a bluegrass lawn and figure 19 crab grass in a lawn. This difficulty, as most other lawn troubles, is best met by using plenty of seed frequently, plenty of fertilizer judiciously, and the lawn mower regularly. Such treatment, while beneficial to the desirable lawn grasses, is tolerated by but few other plants. When applying the seed, rake over the bare places and the places where the undesirable plants are. Plantain, dandelion, and dock are the ones likely to give the most trouble, but even these can be kept in check by this combined treatment. Where they have a foothold it is sometimes necessary to remove them by a trowel or a knife. If it is to be done on a large scale a knife like a short-handled asparagus knife is good. If a large proportion of the lawn is covered with these plants, especially the dandelion and dock, it is better to plow up the lawn and remake it than attempt to eradicate them by hand.

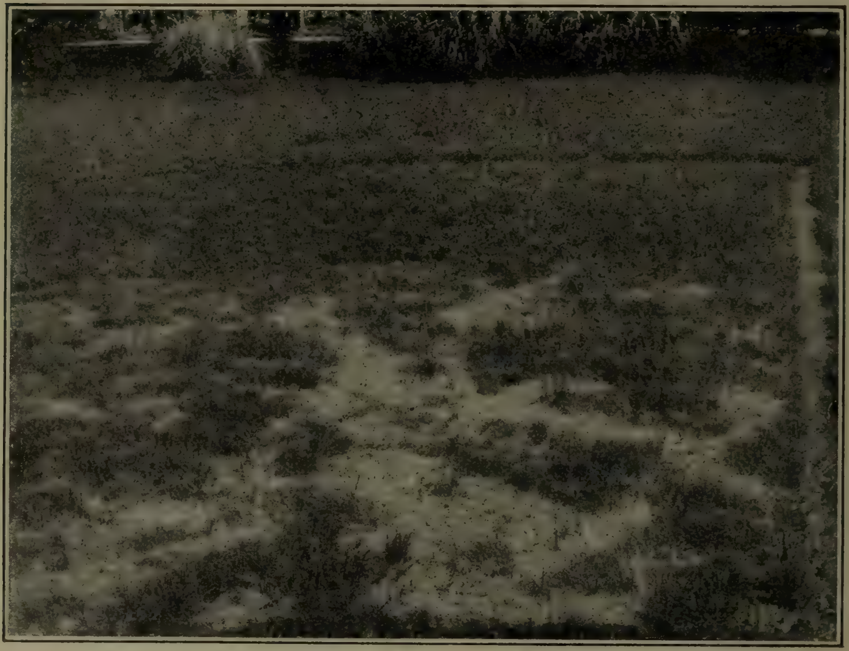


FIG. 19.—Effect of crab-grass on a neglected lawn.

FERTILIZERS.

The fertility of agricultural lands is maintained by thorough tillage, crop rotation, and fertilization. In the lawn, tillage and crop rotation are excluded after the lawn is once established, and fertilization must take the form of surface application, inasmuch as it is not then feasible to incorporate the manures and fertilizers with the soil.

It is difficult to make good soil conditions after a lawn is started when the poor conditions are due to one or all of the soil factors already discussed as causing defective lawns. Fertilization will never make up for a lawn soil poorly prepared. No amount of fertilization will remedy such defects. If the lawn soil has been properly prepared in the first place and enriched with stable manure, lime, and bone phosphate, as described in this bulletin, it should be possible to maintain a lawn in good condition. Lawn clippings should be short and never removed except from very rich land when rains are frequent. When removed they should be caught in a carrier, not raked off. Manure is the best winter mulch, but only well-rotted stable manure should be used, otherwise it will do more harm than good through the introduction of weed seeds. Other coverings are muck and peat, compost, and tobacco stems, all of which make a good mulch. Only a thin covering is required. The benefits to the soil are that the mulch minimizes the damage from alternate freezing and thawing and that it supplies, through the leaching of winter rains and snows, dissolved inorganic and organic constituents, which sink into the soil and thus promote the good conditions necessary for grass growth.

The mulches are all unsightly, and for lawns on good soil properly prepared, from which the grass clippings are not removed, they are not essential after the first year. The manure is allowed to stay on the ground all winter and the coarse material raked off just before the spring rolling.

Ground bone is one of the best lawn applications. Phosphoric acid may also be applied in some form of phosphate rock. Potash can be supplied most economically as muriate of potash. Probably the best practice for the owner of a small place would be to apply a complete commercial fertilizer one year and then ground bone for two years. In regions where it is sufficiently cheap cottonseed meal is an excellent lawn dressing. Dried blood, tankage, fish scrap, sterilized sheep manure are all good fertilizers. All such fertilizers should be used in the fall. Spring application is better than no application, except in the case of dissolved bone or dissolved rock. These fertilizing materials have one advantage over stable manure because they contain no weed seeds. This is an extremely important consideration, so important that unrotted manure should be kept away from the lawn at all times.

Nitrate of soda at the rate of 100 pounds per acre in the spring after active growth begins is also very conducive to grass growth. It shows itself promptly in the darker green of the grass. It should be scattered just before a rain or sprinkling, or dissolved in water and sprinkled over the lawn. Nitrate of soda in smaller applications, about 50 pounds to the acre, is also very desirable as a summer application, as it serves to keep the lawn a bright green during a period when nitrification in the soil is very low, and prevents the parched appearance of the lawn during the summer months.

LIMING.

If a surface application of lime is necessary, it is applied in the fall by scattering broadcast well-slaked lime at the rate of 500 to 1,000 pounds to the acre. Lime is especially beneficial on some soils, making them better suited to bluegrass and other desirable grasses, as well as white clover.

RELATION OF WALKS AND DRIVES TO THE GREENSWARD.

While walks and drives should always be direct, they should be made to conform to the contour of the land instead of being made straight. On small areas, however, there is no advantage in curved walks. The straight line is the shortest distance between two points and in general furnishes the most appropriate approach to the house or outbuilding. The relation of the greensward to the walk or drive, however, is not that of directness but that of beauty.

All walks and drives in private places or in parks should be sufficiently below the level of the greensward to be hidden from the observer standing at right angles to the walk and a few hundred feet from it; that is, to such an observer it should present an unbroken, continuous effect. By this means the apparent extent of the area can be greatly increased, while, if the walk or drive should be elevated above the level of the greensward, the lawn would have the appearance of being cut up into small patches or plats—a very undesirable condition in the lawn of a park or private place.

The edges of the greensward should be carried to the edges of the gutter or walk with a gentle roll rather than with an abrupt bank. Banks are not desirable. Gentle, sloping surfaces are more easily kept in position, more easily grassed, and present a more pleasing appearance than abrupt banks. The gentle roll, when properly made, will serve the same purpose in edging the walk or drive as the abrupt bank.

In general, walks and drives through areas in which lawns predominate should be made of harmonizing material; that is, gravel or dirt roads are to be preferred to any form of pavement. The walks if made of gravel are more in keeping with the general character and aspect of the place than if made of asphalt or either natural or artificial stone. Where there is a great deal of traffic, which is not usually permitted in parks, some form of pavement or permanent walk other than that afforded by gravel must be used. The color of the walk and drive should not present a striking contrast to the greensward. Subdued colors are to be preferred to bright, glistening material for the construction of walks and drives.

RELATION OF TREES AND SHRUBS TO A LAWN.

As has already been suggested, trees and shrubs upon small places should occupy subordinate positions. They should not be scattered promiscuously over the surface of the lawn, but should be used in groups about the border of the grounds, in the bays of walks and drives, and about the foundation of the architectural features of the place. Street trees of necessity must be planted in rows, but all other adornments in the form of trees and shrubs should be used in a free rather than in a formal fashion. Sheared hedges of box or privet along the front of a place or upon the borders of the walks and drives are seldom or never desirable features, unless the whole treatment of the place is formal. A specimen tree or shrub if properly located upon the lawn so as to break up the barrenness of a corner or to limit the vision in any direction is an appropriate object. Oftentimes trees and shrubs can be used to good effect in the immediate vicinity of buildings for softening or relieving staring architectural lines. Of late many plans for the decoration of gardens and grounds have suggested the use of trees and shrubs more in the manner of paling fences and statuary than as living objects carrying individuality. The aim should be to preserve the natural lines and characteristics peculiar to each species of plant used in any decorative scheme rather than to shape the plant into artificial forms. It is the height of folly to prune evergreens in the form of Chinese vases, animals, and articles of furniture. This type of distorture is becoming altogether too prevalent in the mad rush toward the supposed return to nature. Let us not forget that in the treatment of our places that nature unadorned is adorned most, and that the normal, naturally pruned tree or shrub is much more beautiful than the one which has been trimmed into mimicry of some artificial object.

Trees and shrubs should be used to conceal unsightly objects in the foreground or in the background, to give surprises, and to give the feeling of discovery in passing from one portion of a large estate to another, and for the purpose of increasing the apparent length in drives which double back upon themselves in parks and pleasure grounds. Evergreens which are used upon the lawn should have the lower branches preserved so as to produce the effect of arising from the ground not merely by a single stem but as a mass. Shrubbery groups should also be chosen so as to carry the foliage of the group to the greensward rather than to present a considerable extent of bare stalk between the foliage of the shrub and the lawn.

As was stated at the outset, the lawn is the canvass upon which the architectural and landscape effects are to be produced, and all artificial structures as well as plantations should be made to harmonize with the contour of the ground and with the general scheme of the place so as to produce a harmonious and pleasing picture.

BOTANICAL NAMES OF GRASSES REFERRED TO IN THIS BULLETIN.

Bermuda grass	*Capriola dactylon* (L.) Kuntze.
Buffalo grass	*Bulbilis dactyloides* (Nutt.) Raf.
Canadian bluegrass	*Poa compressa* L.
Carpet grass	*Paspalum compressum* (Sw.) Nees.
Charleston grass (*see* St. Augustine grass).	
Crab grass	*Syntherisma sanguinalis* (L.) Dulac.
Creeping bent grass	*Agrostis stolonifera* L.
Herds grass (*see* Redtop).	
Italian rye grass	*Lolium multiflorum* Lam.
June grass (*see* Kentucky bluegrass).	
Kentucky bluegrass	*Poa pratensis* L.
Knot grass	*Paspalum distichum* L.
Large water grass	*Paspalum dilatatum* Poir.
Mesquite grass	*Bouteloua.*
Mission grass (*see* St. Augustine grass).	
Perennial rye grass	*Lolium perenne* L.
Red fescue	*Festuca rubra* L.
Redtop	*Agrostis alba* L.
Rhode Island bent grass	*Agrostis canina* L.
Rough-stalked meadow grass	*Poa trivialis* L.
Seacoast bent grass	*Agrostis alba maritima* (Lam.) Meyer.
Sheep fescue	*Festuca ovina* L.
St. Augustine grass	*Stenotaphrum dimidiatum* (L.) Brong.
Sweet vernal grass	*Anthoxanthum odoratum* L.
Wood meadow grass	*Poa nemoralis* L.

BOTANICAL NAMES OF PLANTS OTHER THAN GRASSES REFERRED TO IN THIS BULLETIN.

Creeping Jenny (*see* Gill-over-the-ground).	
Drooping golden bell	*Forsythia suspensa* Vahl.
English ivy	*Hedera helix* L.
Gill-over-the-ground	*Glecoma hederacea* L.
Hall's honeysuckle (a form of Japanese honeysuckle).	
Japanese honeysuckle	*Lonicera japonica* Thunb.
Japanese mountain spurge	*Pachysandra terminalis* Sieb. & Zucc.
Matrimony vine	*Lycium chinense* Mill.
Moneywort	*Lysimachia nummularia* L.
Myrtle	*Vinca minor* L.
Virginia creeper	*Psedera quinquefolia* (L.) Greene.
White clover	*Trifolium repens* L.

Issued May 18, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 495.

ALFALFA SEED PRODUCTION.

BY

J. M. WESTGATE,
Agronomist in Charge of Clover Investigations,
Bureau of Plant Industry,

ROLAND McKEE,
Scientific Assistant, Bureau of Plant Industry,

AND

M. W. EVANS,
Scientific Assistant, Bureau of Plant Industry.

With notes on the insect enemies of alfalfa seed by F. M. Webster, in charge of Cereal and Forage Insect Investigations, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 17, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Alfalfa Seed Production," prepared by Messrs. J. M. Westgate, Agronomist in Charge of Clover Investigations, Roland McKee, Scientific Assistant, and M. W. Evans, Scientific Assistant, all of the Office of Forage-Crop Investigations of this Bureau, with notes on the insect enemies of alfalfa seed by Mr. F. M. Webster, in charge of Cereal and Forage Insect Investigations, Bureau of Entomology.

The recent wide extension of the culture of alfalfa in the United States has resulted in an increasing demand for seed, which has not been entirely supplied by the seed-raising districts in this country and has necessitated the importation of about 3,000,000 pounds of seed annually. Investigations indicate that with a proper understanding of the essentials for the production of seed crops the entire demand can be supplied with home-grown seed. It is therefore thought desirable that the data regarding the best-known methods of successful production of alfalfa seed be put into a form available for the use of the farmers in the alfalfa seed-growing sections.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5

Conditions affecting the production of alfalfa seed 6

  Thickness of stand 6

  Soil moisture 7

  Climatic factors 8

    Rainfall 8

    Temperatures required for seed development 8

    Influence of seasonal variations in climatic conditions 8

  Influence of honey-gathering insects 9

Handling alfalfa fields for seed 9

  Rate of seeding 9

  Which crop to leave for seed 11

  Foretelling the seed crop 11

  Cultivation of fields 12

  Planking and rolling a stand of alfalfa 13

Harvesting the alfalfa seed crop 14

  Proper stage for cutting for seed 14

  Cutting the alfalfa seed crop 15

  Bunching alfalfa when cut for seed 16

  Stacking the alfalfa seed crop 16

  Effect of rain on alfalfa seed 16

  Thrashing or hulling the seed 17

  Recleaning the alfalfa seed 18

Utilization of alfalfa straw after thrashing the seed crop 18

Seed production in different sections 19

  Seed production on subirrigated lands 19

  Seed production with surface irrigation 20

  Seed production in subhumid sections 21

Alfalfa in cultivated rows 21

  Directions for seeding alfalfa in wide rows 22

  Preventing the drifting of soils 22

  Treatment of the stand 23

  Yields of alfalfa seed from cultivated rows 24

  Alfalfa in cultivated rows in irrigated sections 24

  Alfalfa in cultivated rows in subhumid sections 25

  Alfalfa in cultivated rows in semiarid sections 25

Alfalfa seed compared with hay as a money crop 26

Alfalfa seed yields 27

Continued cropping to seed and its effect on alfalfa plants 28

Drawbacks to the successful production of alfalfa seed 28

Insect enemies of the alfalfa seed crop 29

  The clover-seed chalcis fly 29

  Grasshoppers 30

  The alfalfa caterpillar 30

  The alfalfa weevil 31

Weeds affecting the alfalfa seed crop 31

Adulteration of alfalfa seed 33

Longevity of alfalfa seed 34

Commercial aspects of alfalfa seed production 34

Summary 35

ILLUSTRATIONS.

Page.

FIG. 1. Map of the United States, showing the production of alfalfa seed in 1909 5
2. A heavily seeded isolated alfalfa plant 7
3. A well-set cluster of alfalfa pods 8
4. An implement for renovating alfalfa stands 12
5. Alfalfa thinned to rows 3½ feet apart by the use of a moldboard plow 13
6. A side-delivery buncher attached to an ordinary mower 15
7. A self-rake reaper 15
8. An alfalfa-hulling scene in central Utah 17
9. A type of fanning mill adapted to the recleaning of alfalfa seed 18
10. A mowing machine with dropper attachment 23
11. Adult form of the clover-seed chalcis fly 29
12. Adult form of the alfalfa weevil 31
13. A mature dodder plant on an alfalfa stem 32
14. Seeds of alfalfa and common adulterants and impurities 33

ALFALFA SEED PRODUCTION.

INTRODUCTION.

The importance of the alfalfa-seed industry in the United States is indicated by the advance reports of the official census showing that approximately 15,829,680 pounds of seed were harvested in 1909. (Fig. 1.) The area devoted to alfalfa the same year was approximately 4,638,662 acres.

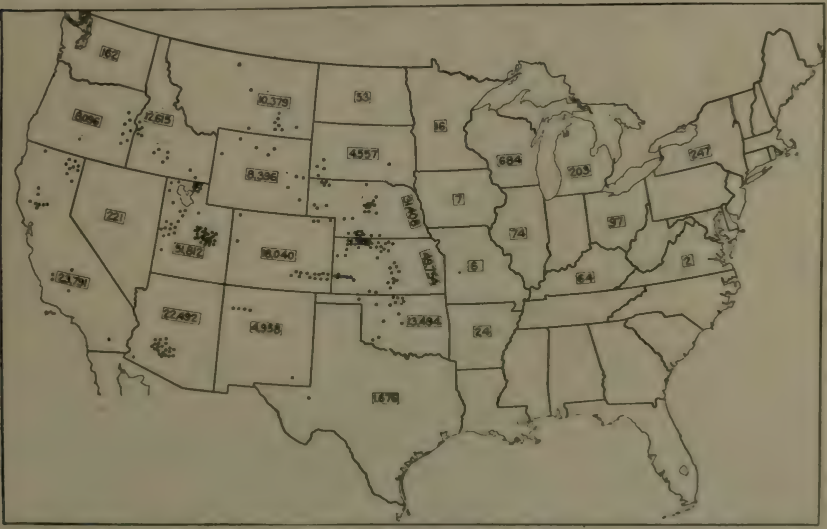


FIG. 1.—Map of the United States, showing the production of alfalfa seed in 1909. Each dot represents 1,000 bushels. The numerals indicate the production in bushels. The location of the dots indicates approximately the seed-producing areas.

The greater portion of the alfalfa acreage is reseeded on an average once in about seven years, although in some sections fields are often allowed to stand for a much longer period. In some sections the use of alfalfa in short rotations with other farm crops makes frequent reseeding necessary. In the potato and cantaloupe growing sections of eastern Colorado it is a frequent practice to hold alfalfa for only two years and then to turn it under as a green-manure crop. The land is then used for succeeding crops of cantaloupes or potatoes, which are in turn followed by alfalfa seeded with a grain nurse crop. In the East, where somewhat unfavorable conditions cause alfalfa stands to deteriorate rapidly, reseeding every few years is necessary. Here the crop is used for forage and little or no seed is produced. Large quantities of seed are required for this reseeding as well as for the seeding of fields not previously in alfalfa. There has also been a large increase in the acreage in the West, especially on the irrigation projects which are being developed. It is thus seen that in the aggregate a large quantity of seed is annually used. The greater part of this seed is grown in the United States, but about 3,000,000 pounds are annually imported. The imported seed is an important factor in determining the price of seed in this country.

It is the province of this bulletin to treat only of the seed production of alfalfa and the factors affecting it. Other phases of alfalfa raising are discussed in separate Farmers' Bulletins, any or all of which may be secured upon application to Members of Congress or to the Secretary of Agriculture.[1]

CONDITIONS AFFECTING THE PRODUCTION OF ALFALFA SEED.

The factors of greatest importance in connection with the production of alfalfa seed are thickness of stand, soil moisture, and such climatic factors as rainfall and temperature. The local variation of one or more of these factors accounts for the great fluctuations in seed yield often observed in a given season in a single locality and even on the different parts of the same farm.

THICKNESS OF STAND.

Experiments and observations have shown that thin stands of alfalfa tend to make good yields of seed much more certain. The reason for this lies largely in the fact that the thin stand permits a more complete development of the individual plants. The greater amount of sunlight received by each plant in thin stands also tends to increase the production of seed. The accompanying illustration (fig. 2) shows the large number of seed pods produced by an isolated plant. It is a matter of common observation that isolated plants along roadsides and in fence rows ordinarily produce much heavier crops of seed than do the plants in near-by fields. Figure 3 shows the appearance of a well-set cluster of seed pods.

---

[1] Farmers' Bulletin 194, entitled "Alfalfa Seed," by Edgar Brown, discusses adulteration, impurities, methods of testing germination, etc. Additional details concerning methods of testing the germination and purity of alfalfa seed are given in Farmers' Bulletin 428, by F. H. Hillman.

Farmers' Bulletin 339, entitled "Alfalfa," by J. M. Westgate, contains a general discussion of alfalfa as a farm crop.

Farmers' Bulletin 373, entitled "Irrigation of Alfalfa," by Samuel Fortier, discusses methods of irrigating alfalfa as practiced in the Western States.

Circular 24, Bureau of Plant Industry, entitled "Alfalfa in Cultivated Rows for Seed Production in Semiarid Regions," by Charles J. Brand and J. M. Westgate, discusses methods of cultivation designed to combat the development of weeds.

SOIL MOISTURE.

In growing alfalfa for seed the moisture content of the soil is a most important and critical factor. It must be sufficient to enable the plant to mature its seed crop and yet not enough to induce the starting of the crown shoots in advance of the maturation of the seed crop, as the setting of seed is often greatly lessened when the growth for the succeeding crop of stems begins. The margin between too much and too little water is a very narrow one, and it is owing more to this fact, perhaps, than to any other that alfalfa-seed production is so often uncertain.

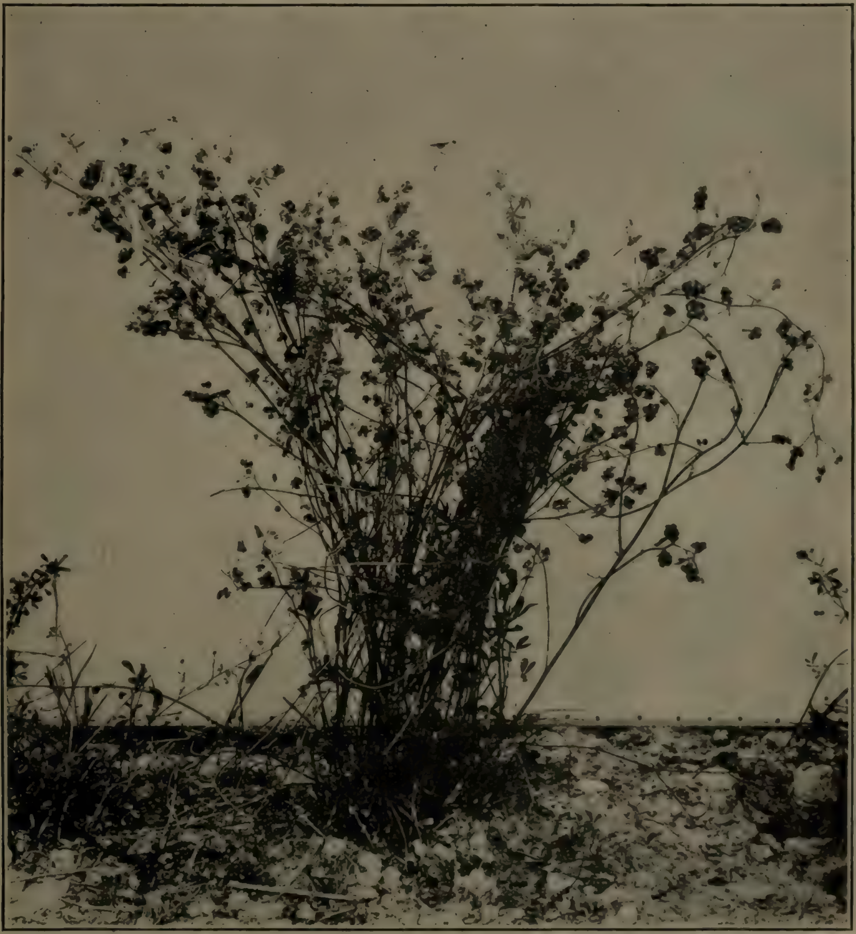


FIG. 2.—A heavily seeded isolated alfalfa plant grown near Washington, D. C., where the climatic conditions are much more unfavorable to the production of alfalfa seed than in the semiarid sections.

CLIMATIC FACTORS.

That climatic conditions have an important bearing in growing alfalfa for seed is shown by the fact that successful seed crops are produced only under certain climatic conditions. The alfalfa plant requires a somewhat prolonged period of warm. dry weather to mature a crop of seed.

Rainfall.—The factor of rainfall is important in that it affects directly not only the soil-moisture conditions, but also the temperature and humidity of the air. It also has a direct effect upon the flowers if the plants are in bloom. If the period of rainfall is somewhat extended or the amount quite large, the effect is detrimental to the seed crop. An annual rainfall of at least 18 inches, properly distributed, is usually necessary for a seed crop. In such sections as eastern Kansas and Nebraska, where the normal rainfall somewhat exceeds 30 inches a year, good seed crops are obtained only in the drier years.

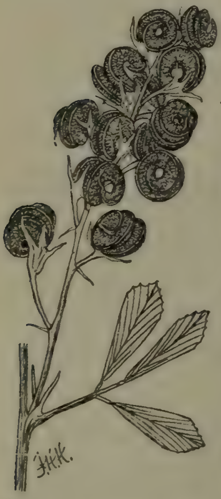


FIG. 3.—A well-set cluster of alfalfa pods.

Temperatures required for seed development.—It has been found that relatively high temperatures are necessary during the period when the seed crop is setting and developing. In the southwestern portion of the United States and occasionally elsewhere the extreme summer temperatures combined with hot, dry winds may, however, result in the blasting of the flowers.

Continued cool nights seriously retard the setting of the seed. Late summer or early fall frosts frequently occur in most mountain districts. These frosts have a greater or less effect on the development of any seed which may already have been set in the young, partly developed pods. Occasional light frosts seem merely to retard the development of the seed, but a severe, killing frost or continued light frosts will seriously injure the seed crop. Seed has been observed setting as late as November 13 in the vicinity of Washington, D. C., several weeks after killing frosts had occurred, but which were followed by 10 days or 2 weeks of relatively warm, growing weather.

Influence of seasonal variations in climatic conditions.—The seasonal variation in rainfall, temperature, cloudiness, etc., is of prime importance. A given section may in one season give an abundant yield only to be followed by a practical failure of the seed crop the next year, even though good hay yields may be produced. The effects of seasonal variations in rainfall can to a certain extent be offset by proper methods of planting, cultivation, etc.

INFLUENCE OF HONEY-GATHERING INSECTS.

Nearly all experiments show that if insects are excluded from alfalfa flowers by means of screens very few or no seeds are produced, whereas adjoining plants not screened produce an abundance of seed if other conditions are favorable. However, in northern Montana heavy seed crops have been obtained in certain seasons when general observations failed to indicate the presence of insects in numbers anywhere near what was considered sufficient to account for the fertilization of the flowers. The principal effect of the insects appears to be the tripping or releasing of certain of the flower parts, which operation is essential to fertilization. This tripping can be done artificially by thrusting a pencil point or other object into the flower or by pressing the flower between the thumb and finger, when the tripping can readily be observed.[1] Observations indicate that the ordinary honeybee trips the flower much less frequently than do bumblebees or some of the wild bees. The honeybee ordinarily inserts its proboscis at the side of the tripping mechanism without releasing it, while the bee's weight on the flower is not sufficient to set off the tripping mechanism as is the case with the bumblebee. The small wild bees trip the flower owing to the fact that they must struggle to reach the nectar, and in this struggling they release the tripping mechanism. Ordinarily the alfalfa flower is fertilized with pollen from some other flower, but it is able to set seed with its own pollen if the flower be tripped.

HANDLING ALFALFA FIELDS FOR SEED.

Alfalfa fields are seldom used solely for seed-producing purposes. Hay is generally the main object of planting. Seed production is more uncertain under such conditions than when the crop is seeded thinly. It is, however, possible to increase the certainty of a satisfactory seed crop even with the thicker stand by giving attention to moisture conditions, etc., as explained elsewhere. Lands under irrigation which receive seepage waters from other fields should be avoided, as should also the lower lying fields in the subhumid regions, where even a normally wet summer may cause the plants in such places to produce such a rank vegetative growth as to ruin the chances for seed.

RATE OF SEEDING.

It is a matter of common observation that isolated plants are usually heavy seed producers, while alfalfa growing near by in thick broadcasted stands may be setting little or no seed. As a rule the stand should be thin enough so that there will be no crowding. Seed setting is apparently best where the stand is so thin that each plant makes a strong individual development. Sunlight appears to be a factor influencing the development of flowers and seed, and when reduced below certain limits its effect in cutting down the quantity of the seed produced is very marked. Where the stand is thin the sun can reach a surface of flower-bearing stems nearly twice as great as where the stand is so crowded that only the flowers near the top of the plant can receive sufficient light for the best development of seed. If the crop is to be used primarily for seed-producing purposes, the common practice is to seed at about half the rate customary when sown for hay. This diminution of the rate calls for 4 to 10 pounds of seed to the acre in the different sections according to differing conditions. When plants are grown in wide cultivated rows, as may sometimes be practicable, about 2 pounds of seed per acre is sufficient. This is much less seed than is required when broadcasted or when seeded in ordinary drill rows 6 or 7 inches apart. Thorough preparation of the soil, a firm, moist seed bed, and the use of a drill lessen the amount of seed necessary to be used.

---

[1] For a more detailed description of this process, see Circular 24, Bureau of Plant Industry, pp. 8-10.

Some difficulty is often experienced in adjusting an ordinary wheat drill so that it will drop the alfalfa seed thinly enough. This may in a measure be overcome by mixing some foreign material, as corn chop, sawdust, or wheat bran with the seed. It is also possible to reduce the feed by use of strips of leather in the drill feed pits. A much thinner stand can also be had by entirely stopping up two or three holes out of every four, thus making the rows 12, 18, or 24 inches apart when a 6-inch drill is used. Whatever kind of implement is used to make the seeding, it is suggested that it be first tested on bare, hard soil, with the shoes just touching the ground, as in this way it can be readily seen at what rate the seed is being dropped. The necessary regulations can then be made before the actual seeding operations commence in the field, where it is always difficult to know just how rapidly the seed is being fed into the ground. Planting in wide drills does not necessarily reduce the yield of the incidental hay crops. An experiment performed at Chico, Cal., showed that the incidental cuttings from the ordinary broadcasted stands averaged 3,169 pounds of hay to the acre, as compared with 4,191 pounds to the acre obtained from the stand in rows 18 inches apart. In this particular experiment the broadcasted stands produced no seed, while the stands in 18-inch rows gave yields as high as 124 pounds to the acre. The yields obtained from plats in which the plants were in rows 4 feet apart were even larger, as shown on page 24.

WHICH CROP TO LEAVE FOR SEED.

The crop to be left for seed should be that which will mature during the period of the best conditions as regards soil moisture and heat. In sections along the fortieth parallel of latitude where three crops of hay are normally produced it is usually customary to cut one hay crop and to let the next crop stand for seed. This method brings the seed setting in August, which is usually about the right time. In the more northern sections and at the higher altitudes farther south it may delay the second crop too long to let the first crop stand for a full cutting of hay. Under such conditions an early clipping should be made. Such clipping is beneficial in that it evens up the growth, induces uniform blossoming, and tends also to bring the setting of seed at the right time in the summer. In the Southwest, as in Arizona and the interior valleys of California, two or sometimes three cuttings of hay may be obtained before letting the crop stand for seed, but the practice is not uniform over the entire area. Better early seed crops can be obtained in Arizona and in the Imperial Valley of California than farther north. The present indications are that this is partly due to climatic conditions, but also to some extent to the attacks of the little insect called the alfalfa and clover-seed chalcis fly, which occurs most numerously early in the season in northern California, but considerably later in Arizona and in the Imperial Valley. It appears to be the rule in most sections to let what would otherwise be next to the last hay crop stand for seed. It usually takes as long for one seed crop to mature as for two crops of hay; hence, little or no growth is commonly made after cutting the seed crop, not more than is desirable for the proper protection of the plants during the ensuing winter.

FORETELLING THE SEED CROP.

If there is to be a light and consequently unprofitable setting of seed, as is often the case, it is important that such fact be known as early as possible, so that the crop may be cut at once for hay and the succeeding hay crop allowed to begin its development. If the conditions before blooming are such as to produce a rank vegetative growth it is a fairly sure indication that the chances are poor for seed. If, however, the soil becomes dry just at this time, a fair seed crop may sometimes be obtained. Also, if the blossoms appear sparingly or if they appear freely but blast or wither without setting pods, the chances for a seed crop are greatly reduced and the crop should be cut at once for hay. After this cutting another fair crop of hay may usually be secured. If, however, the cutting be delayed too long it will be at the expense of the next crop, as the time for its development may be short. Another indication that a seed crop is likely to be very light is shown when the basal shoots begin to grow in anticipation of the succeeding crop. The development of these basal shoots takes place at the expense of seed development on the older stems.

If heavy rains occur or if continued cold, damp, rainy weather conditions prevail when the plants are in full bloom the prospects of a seed crop are greatly reduced.

The chances for seed are good if the reverse of the above conditions prevail and the plants have made a medium stocky, well-branched growth with an abundance of bloom, especially if the warm, dry conditions continue. It is practically impossible, however, to infallibly foretell the seed crop. The crop is not assured until the plants are well loaded with clusters of well-filled pods.

CULTIVATION OF FIELDS.

The vegetative vigor of alfalfa is usually increased by any cultivation which loosens up and aerates the soil. By this process a mulch is formed which conserves the moisture. Whether this is beneficial to the seed crop depends upon the vegetative vigor of the plants at the time. Where past experience or observation indicates that the growth will be normally vigorous a light cultivation will be likely to work a positive injury to the seed crop, in that it will unduly stimulate the vegetative growth. However, on soil that becomes dry and where the plants promise to make but a light growth, an intelligent use of some such implement as a disk harrow, spring-tooth harrow, or alfalfa renovator may be utilized to overcome this condition. (Fig. 4.)

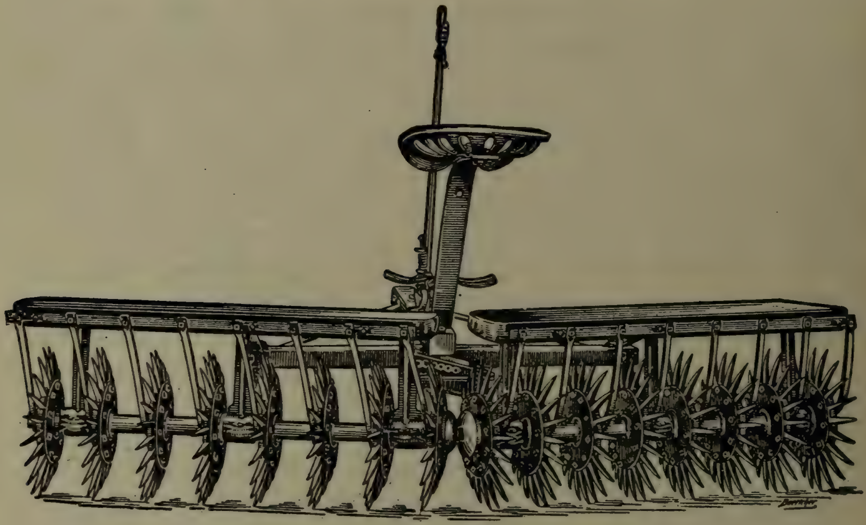


FIG. 4.—An implement for renovating alfalfa stands.

Such cultivations should be done early in the spring, before the plants start into vigorous growth.

It is sometimes the practice to run a heavily weighted disk three or four times over the field early in the spring in order to thin the stand for increased seed yields. When an ordinary plow is used it is necessary to have a very sharp share and to plow out three narrow furrows for every 8-inch width left unplowed. In addition to this it is advisible to harrow heavily later with a spike-tooth harrow in order to level down the ridges. It is also best to give some subsequent cultivation to prevent the alfalfa which has been turned under from again growing and thickening the stand. This subsequent cultivation will also serve to hold the weeds in check. (Fig. 5.)

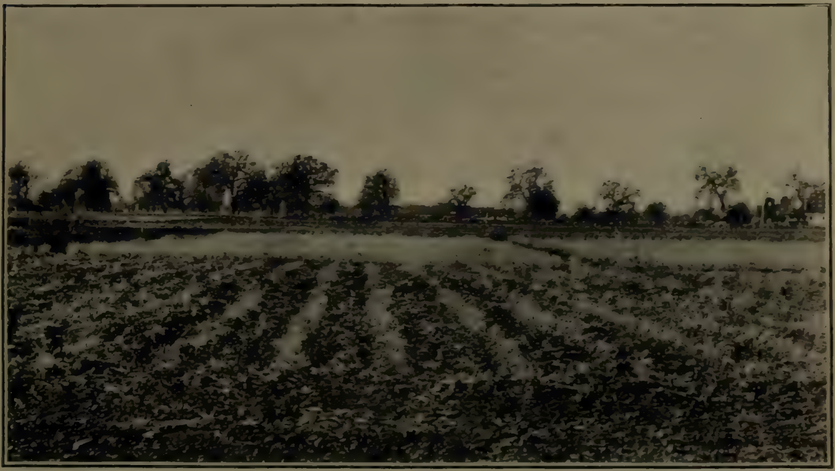


FIG. 5.—Alfalfa (originally a broadcasted stand) thinned to rows 3½ feet apart by the use of a moldboard plow.

PLANKING AND ROLLING A STAND OF ALFALFA.

It has been observed in a few instances on a small scale that rolling or planking down a stand of alfalfa just when in full bloom apparently has a beneficial effect on the seed crop. This operation might also be done with a brush drag. This effect is explainable in two ways: (1) The bending over of the stems may sufficiently retard the vegetative growth of the plants as to induce heavy seed setting. This explanation accords with observations in connection with other crops where anything that interrupts or retards the normal vegetative growth increases the setting of fruit or seed. (2) It is also possible that the tripping of the flowers that takes place when the plants are rolled has the same effect as the tripping of the flowers by insects and results in seed setting. If tripping insects are abundant in a locality the rolling of the plants might have little effect in increasing seed yields, but if such insects are not numerous at the time the plants are in bloom it is obvious that rolling may be an efficient factor in causing the development of seed. It has been observed that about half the open flowers on a plant may be tripped by such an operation as rolling or planking. However, this practice needs further trial before positive statements as to its value can be made. It is suggested that the first attempts in any community be made on a small scale, and in each instance a portion of the field be left untreated to serve as a basis of comparison.

HARVESTING THE ALFALFA SEED CROP.

Considerable care is necessary in handling alfalfa for seed in order to prevent shattering. The machinery for handling a seed crop up to the time it is ready for the huller is largely the same as for hay, but for the best work some modifications are necessary.

PROPER STAGE FOR CUTTING FOR SEED.

All the pods on an alfalfa plant do not ripen at the same time, nor do all the plants in a field mature at the same time. The tendency on the part of the ripened pods to shatter often causes some loss of seed before the majority of pods mature. For this reason it is necessary to cut the crop when the greatest percentage of good seed can be saved without trying to save either the very early or the late-maturing seed. Ordinarily the crop should be cut when from two-thirds to three-fourths of the pods have turned brown. It has been found by experiments that seed gathered from pods that have turned to only a light-straw color will make a fair quality of seed although lacking somewhat in plumpness.

In order to determine the quality of seed harvested at different stages of maturity a series of experiments was made, the results of which are shown in Table I. The germination test was continued for five days and was made when the seed was about 3 months old.

TABLE I.—*Effect of harvesting alfalfa seed at different stages of maturity.*

Stage of maturity.	Percentage of seed found to be—			
	Dead.	Alive.	Hard.[1]	Capable of sprouting promptly.
Pods green and not yet fully filled out	94	6	0	6
Pods green but full size	73	27	12	15
Pods just turning from green to a light-straw color; plump	17	83	58	25
Pods turned to a light brown; plump	11	89	69	20
Pods turned brown; fully matured	9	91	68	23

[1] The so-called "hard seed" is perfectly good, but the seed coats are so hard that they are unable to take up moisture and sprout promptly. This condition disappears as the seed becomes older and is usually negligible in seed 2 or 3 years old. In sowing seed less than 1 year old the proportion of seed that will not sprout promptly should be determined and the necessary increase in the amount of seed to be sown should be provided for.

CUTTING THE ALFALFA SEED CROP.

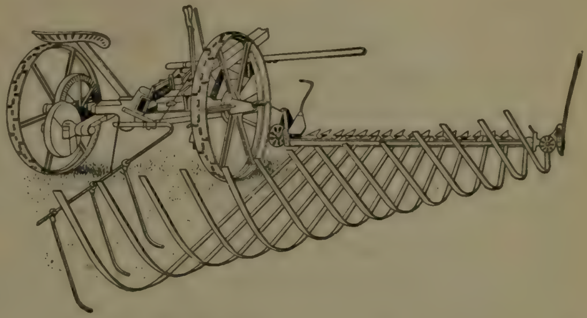


FIG. 6.—A side-delivery buncher attached to an ordinary mower; it delivers the crop to one side, out of the way of the team and machine on the next round.

The ordinary mower is sometimes used for cutting the alfalfa seed crop. This machine without attachments is not entirely satisfactory, owing to the shattering of the seed by the wheels and by the trampling of the horses on the succeeding round, but various devices may be attached for removing the swath from behind the cutter bar. An attachment called a "rower" or "swather," either with or without an additional bunching device, is often used. (Fig. 6.) In some sections the old-fashioned self-rake reaper is used and this implement is probably the most satisfactory for the purpose where the growth is not too heavy. (Fig. 7.) This machine has a platform or table behind the cutter bar, and the revolving rakes cast off the gavels or bunches as they accumulate. Where alfalfa is not too heavy an ordinary

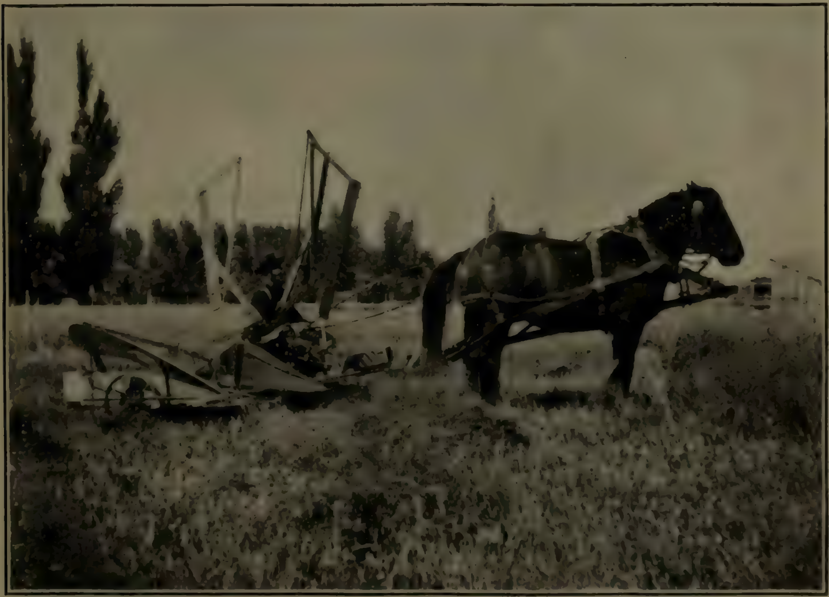


FIG. 7.—A self-rake reaper. The arms, which rotate when the machine is in motion, remove the accumulated bunches of alfalfa and leave them in regular piles behind the machine.

grain binder can be used. These implements do away with the necessity of raking the mowed plants, an operation which usually results in much shattering of the seed but which can hardly be avoided where only an ordinary mower without some such attachment is available.

BUNCHING ALFALFA WHEN CUT FOR SEED.

In some sections it is not considered good practice to allow the cut crop to remain on the field in small bunches as dropped by a self-rake reaper or in a light swath as it would be left by a swathing attachment. When thus left there is a tendency for the seed to shatter, especially when alternately wet and dried as in the case of frequent rains or even heavy dews; consequently the cut crop is bunched with pitchforks into small shocks. The shattering incident to tearing the bunches to pieces when loading may be avoided by making them so small that each can be lifted to the rack in one forkful.

STACKING THE ALFALFA SEED CROP.

Owing to the fact that a machine to hull or thrash the cut alfalfa is not usually available immediately after harvesting, it is often necessary to stack the alfalfa to await the coming of the huller or thrasher. If the crop has been cut and bound with a self-binder and is to be stacked it is important that the bundles be left in the shock for some time, as otherwise they will be damp in the center and will be likely to heat in the stack and ruin the seed. When stacking is necessary the bunches or bundles are pitched upon hayracks with a matched-floor bottom or with a tarpaulin stretched over the bottom if it is not perfectly tight. This catches much of the shattered seed which otherwise would be lost. A foundation of hay or straw will protect the seed on the bottom of the stack and catch any seed that may shatter. No special method of stacking the alfalfa is necessary other than to keep the middle reasonably full and hard so that in case rains do occur a minimum amount of water will enter the stack. The stacks should be comparatively narrow to avoid any possible danger of heating. Care should be taken to handle the alfalfa from the rack in exactly the reverse order from that in which it was loaded so that bunches may not be pulled apart and the seed shattered. If any grass hay or even millet or sorghum be available such material should be used to top the alfalfa stacks, if there is any likelihood of rains. In the absence of such materials it may prove profitable to provide canvas covers for the stacks if rain is anticipated. These canvas covers may be spread on the ground around the machine when hulling to catch any pods or seed which may shatter.

EFFECT OF RAIN ON ALFALFA SEED.

The three principal effects of rain on the alfalfa seed crop after it is mature are: (1) Shattering of the seed; (2) discoloration of the seed;

(3) premature sprouting of the seed if the moist condition continues. For these reasons it is essential that as little rain as possible reach the alfalfa from the time it is mature until it is marketed. The germination of seed which has been repeatedly wet and dried is somewhat although not always materially reduced.

THRASHING OR HULLING THE SEED.

A regular alfalfa huller is the most satisfactory machine for hulling the seed, but many sections do not produce enough alfalfa seed to justify the purchase of such a machine. (Fig. 8.) Where these conditions exist an ordinary thrasher can be used. By screwing down the concaves and providing a special set of alfalfa sieves fairly satisfactory results can be attained. By this method a good deal of seed is left in the straw, sometimes enough to pay for running it through again. It is the custom in some parts of the country where both thrashers and hullers are used for the hullers to follow the thrashers and thrash out the alfalfa straw piles for half the seed obtained. In addition to the two methods just cited grain separators are sometimes fitted with hulling attachments. While the use of the ordinary thrashing machine has sometimes been unsatisfactory it is generally true that imperfections are due to lack of proper manipulation of the machine, but some makes of machines are better adapted than others for this work. In sections where ordinary hullers are not available there is no doubt as to the advisability of using the thrashers rather than to forego the seed crop entirely. Failure to appreciate the fact that the usual thrashing machine can be adapted to this purpose has often

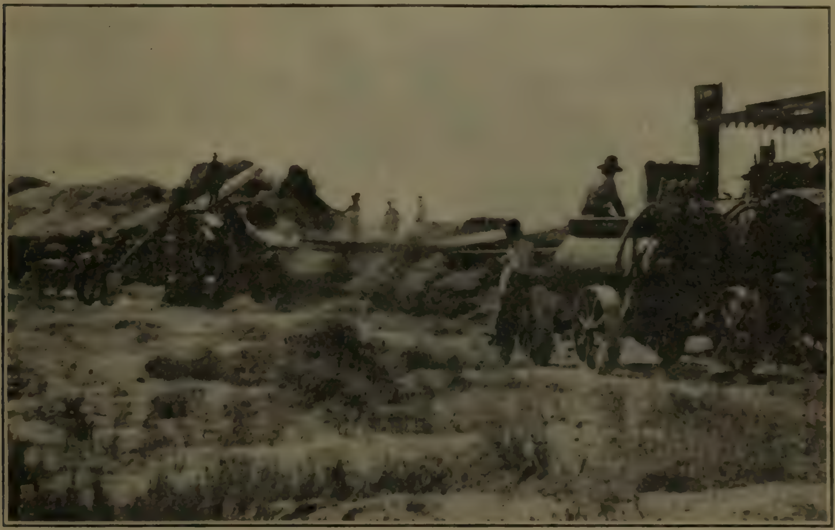


FIG. 8.—An alfalfa-hulling scene in central Utah.

resulted in the loss of a profitable seed crop in sections where seed production is not often attempted.

It is very difficult to hull alfalfa seed in damp weather or when the plants are at all moist. Hulling can be accomplished most readily when the weather is very dry and hot or when dry and very cold.

RECLEANING THE ALFALFA SEED.

Alfalfa seed as it comes from the machine is not usually in a marketable condition. It contains small stones, clods, pieces of stems and pods, and often a considerable quantity of weed seeds, as well as more or less shriveled alfalfa seed. The bulk of these impurities must be removed before the seed can be sold to advantage. A specially modified fanning mill (fig. 9) or other cleaning device will remove the lighter seeds as well as most of the portions of pods and stems, while a special set of sieves will remove the weed seeds and small stones and clods which differ in size from the alfalfa seed. As it is usually impracticable for the individual farmer to own a complete recleaning outfit, the reader is referred to page 34, where the cooperative possibilities in this matter are discussed.

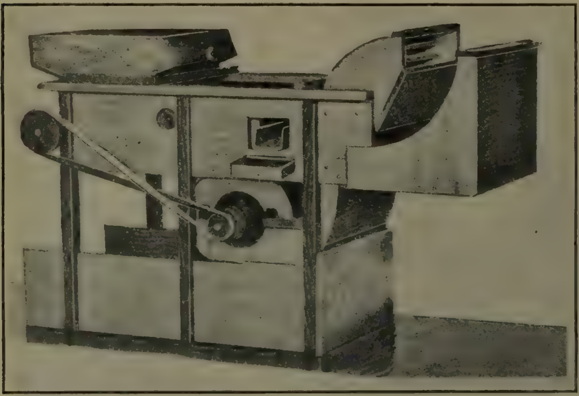


FIG. 9.—A type of fanning mill adapted to the recleaning of alfalfa seed.

UTILIZATION OF ALFALFA STRAW AFTER THRASHING THE SEED CROP.

The alfalfa straw remaining after the seed is removed is not nearly so valuable as the same quantity of alfalfa hay, but it nevertheless contains a great deal of valuable feeding material and can be used as roughage for stock. Table II gives an analysis made by the Bureau of Chemistry, showing the constituents of alfalfa straw as compared with the average of 21 analyses of alfalfa hay taken from Henry's "Feeds and Feeding."

TABLE II.—*Composition of alfalfa straw as compared with that of ordinary alfalfa hay.*

Constituents.	Alfalfa.	
	Straw.	Hay.
	Per cent.	*Per cent.*
Water	6.26	8.4
Ash	5.13	7.4
Protein	6.75	14.3
Crude fiber	47.82	25.0
Nitrogen-free extract	32.20	42.7
Ether extract (fat)	.84	2.2

The feeding value of the straw is probably nearly half that of first-class alfalfa hay and is probably about equal, pound for pound, to ordinary grass hay. It is sometimes baled and put on the market, but ordinarily it is used as bedding or is fed as roughage to stock in the winter. It is suggested that very coarse straw be run through a feed cutter to make it more palatable to stock. Where it can not be utilized as feed it may be put back on the ground and plowed under to increase the humus content of the soil. This is a much better practice than burning the straw, as is sometimes done when no demand exists for it as feed.

SEED PRODUCTION IN DIFFERENT SECTIONS.

Probably more than two-thirds of the alfalfa seed in the country is produced in sections where the natural rainfall is too scant for the production of good yields of most cultivated crops without irrigation.

SEED PRODUCTION ON SUBIRRIGATED LANDS.

Considerable areas of land in the arid or semiarid sections of the country are supplied with water near enough to the surface so that the roots of the alfalfa may reach it and thrive in spite of the lack of rainfall. Such lands are classed as subirrigated and are important in that a deep-rooted crop like alfalfa makes them of value without artificial surface irrigation after the plants are well grown and have extended their roots down to the moist layers of soil. On lands of this class the supply of irrigating water which on other lands is necessary for the crop of the first two years is rendered available for use elsewhere on the farm. These subirrigated lands are among the best for alfalfa-seed production. The semiarid sections are usually characterized by hot summers, which are favorable to the production of seed if other conditions are right. The principal alfalfa-seed-producing lands of this type are located in Arizona, Utah, Idaho, California, Colorado, Wyoming, Montana, New Mexico, Oklahoma, and eastern Oregon. When starting alfalfa on subirrigated land it is usually advisable, when possible, to give irrigation until the roots are able to reach the water-bearing strata below. The handling of these fields for seed production is not materially different from the methods practiced in more moist sections. The first growth may be cut for hay or clipped back to insure more nearly uniform flowering. In the southern sections a full first cutting of hay can be obtained, while in the extreme north only a very short clipping can be made, and then barely enough time may remain for the maturing of a seed crop before frosts or cold nights retard the setting of seed.

SEED PRODUCTION WITH SURFACE IRRIGATION.

Throughout the nearly arid sections of the United States where most of the alfalfa is produced with the aid of surface irrigation, considerable areas are devoted to the production of seed. Where an abundance of water is available for irrigation, and especially where there is an active demand for hay at good prices, the usual custom is to make as many cuttings of hay as possible and not rely to any considerable extent on seed production as a source of revenue. A common practice in some sections where a shortage of water for irrigation prevails during midsummer is to let the second crop stand for seed, as it is usually considered necessary to reduce the amount of irrigation given a field if it is to set its best seed crop. When alfalfa is to be raised primarily for seed in irrigated sections, a thinner seeding is advisable than if the hay crop is the prime consideration. From 15 to 20 pounds of seed is the quantity usually used when hay alone is desired, and from 5 to 10 pounds is sufficient where the stand is to be used largely for seed-producing purposes. The seeding can be either broadcast, in close drills, or in wider rows or drills. Preliminary experiments show that it may be profitable to have the rows as much as 3½ feet apart to allow cultivation the same as corn. This method is proving satisfactory in semiarid sections, where it is necessary to conserve the supply of soil moisture. It has not been thoroughly demonstrated, however, that this method can successfully compete with the more thickly seeded plants when grown under irrigation; but the high seed yield of widely isolated plants as well as that of small experimental plats under irrigation such as referred to on page 24 indicates that this method may also be of considerable value in irrigated sections, especially where there is a material shortage of water. It is seldom desirable to let a crop stand for seed during the first two years of its growth, and since it is utilized for hay during this time the stand may be thicker than would be best for seed production later. It is therefore sometimes practicable to have the stand thick and cut it for hay the first two years, after which it is thinned by the method outlined on page 13.

SEED PRODUCTION IN SUBHUMID SECTIONS.

The subhumid sections may be defined as those regions which are more moist than the semiarid sections but where summer droughts are somewhat frequent and where some care is therefore usually necessary to conserve the soil moisture if satisfactory crops are to be produced. If the semiarid sections along the fortieth parallel be defined as those having the rainfall varying from 10 to 22 inches, then the subhumid sections would comprise those where the rainfall ranges from 22 to 30 inches. Alfalfa seed can not usually be produced profitably where the annual rainfall is more than 30 inches; as a consequence, the humid sections, lying principally to the east of the subhumid sections, are not adapted to the production of alfalfa seed. The alfalfa in the subhumid sections when intended for seed as well as for hay production is usually sown broadcast in comparatively thin stands. In the seasons of severe drought, when the corn crop is practically a failure, it is not uncommon for the alfalfa fields to produce extremely large yields of seed, so that the aggregate income from a farm having a fair proportion of its acreage devoted to alfalfa may compare favorably with the income during a normal season.

ALFALFA IN CULTIVATED ROWS.

Although alfalfa is usually raised in thin broadcasted stands when seed is the main object, yet the indications are that it is sometimes an advantage to have the seeding made in rows sufficiently far apart to permit cultivation and also to insure the maximum individual development of the alfalfa plants. The yields of hay under such treatment are larger than would ordinarily be supposed, as in 18-inch rows it has been observed even to exceed the yield obtained from associated broadcasted stands. (See p. 10.) The growing of alfalfa in cultivated rows has been tried in an experimental way in many sections of the country and has in nearly all instances given promising results; but this method is not recommended for general use, except where seed is to be produced whenever seasonal conditions are favorable, since the increased expense of keeping down the weeds, especially the first year, is not justified by the returns from the hay crop.

The special feature of the possibilities of this method in the semiarid section is the fact that it furnishes a money crop for the farmer under conditions which do not usually produce maximum yields of ordinary field crops. In other words, the droughts which produce the heavy seed crops in the subhumid and humid sections, such as central and eastern Kansas, are usually an every-season occurrence in the semiarid sections. Under irrigation the seed development usually occurs at a period when there is apt to be a shortage of irrigating water, and for this reason the method promises to be very practicable inasmuch as plantings in wide rows demand but little water for maximum yields of seed.

DIRECTIONS FOR SEEDING ALFALFA IN WIDE ROWS.

If it is not the intention to intertill the alfalfa, the rows may be a less distance apart than when it is designed to cultivate them each season. Good seed crops have been obtained from rows 8, 16, and 24 inches apart, but with the exception of the last distance it is practically impossible to cultivate between the rows after the plants have become well grown. When it is planned to cultivate during successive seasons it is necessary to seed the rows about 42 inches apart, for if planted in narrower rows little space will be available for cultivation, as the plants stool considerably. Inasmuch as the growing of alfalfa in cultivated rows is comparatively new much still remains to be developed in connection with the most suitable farm practices concerning the details of the seeding and handling of the crop. It is often possible to adapt the farm machinery already at hand to this work. It is usually practicable in sections growing corn, Kafir corn, sorghum, or milo maize to seed the rows the same distance apart as is customary for these crops. This practice permits the use of the ordinary planting and cultivating machinery in connection with the alfalfa crop.

An ordinary wheat drill can be adapted for planting alfalfa, as suggested on page 10, or a corn drill can be used if the holes are filled with Babbitt metal and then reamed out so that each will drop 6 to 10 alfalfa seeds at a time. Satisfactory results have also been obtained by using an onion-seed plate in a corn drill. A corn planter with the holes properly babbitted and reamed can be used if it is desired to have the plants in hills to permit of cross cultivation. A sugar-beet planter might also be utilized with some modifications.

PREVENTING THE DRIFTING OF SOILS.

The fact that the young alfalfa seedlings make a relatively slow growth, combined with the necessity of an exceedingly thin stand when seed production is the ultimate object, often makes difficult the prevention of the drifting or blowing of the soil for the first few months after seeding. A number of methods are available for reducing this injury, among which may be mentioned the seeding of alternate rows of grain with the alfalfa, the grain to be destroyed when the subsequent cultivations are made. Where rows of corn or sorghum are used as windbreak protection they should be made a rod apart across the field and at right angles to the direction of the prevailing winds. Where new sod is broken up, strips of the original sod left at rod-apart intervals will tend to retard the blowing of the soil. Some protection is also given by planting the alfalfa in listed furrows, leaving the ground in ridges which materially reduce the drifting of the soil, though sometimes the winds are so heavy as to cause the plants in the furrow to be entirely covered up. A more extended discussion of the blowing of soils is given in Farmers' Bulletin 421,[1] which may be obtained free upon application to a member of Congress or to the Secretary of Agriculture.

TREATMENT OF THE STAND.

When alfalfa is seeded in wide cultivated rows the treatment the first season will be that which will most effectively hold the weeds in check and at the same time reduce as much as possible the blowing of the soil. The young alfalfa plants are ordinarily so small that it is somewhat difficult to kill the weeds by cultivation without burying the plants. This danger can in a measure be avoided by the use of properly constructed fenders, or an ordinary corn box may be attached to the cultivator, which should also be provided with narrow shovels. Unless the plants show signs of setting seed the first season it will ordinarily not be necessary to give them any attention other than the cultivation as indicated, but should the plants show signs of developing a seed crop they should be clipped back to a height of 4 or 5 inches. During the second season the first growth of the plants should be cut back not later than the time of early bloom to a height of 4 or 5 inches. Ordinarily the next growth may then be allowed to stand for seed. Figure 10 shows a field in the

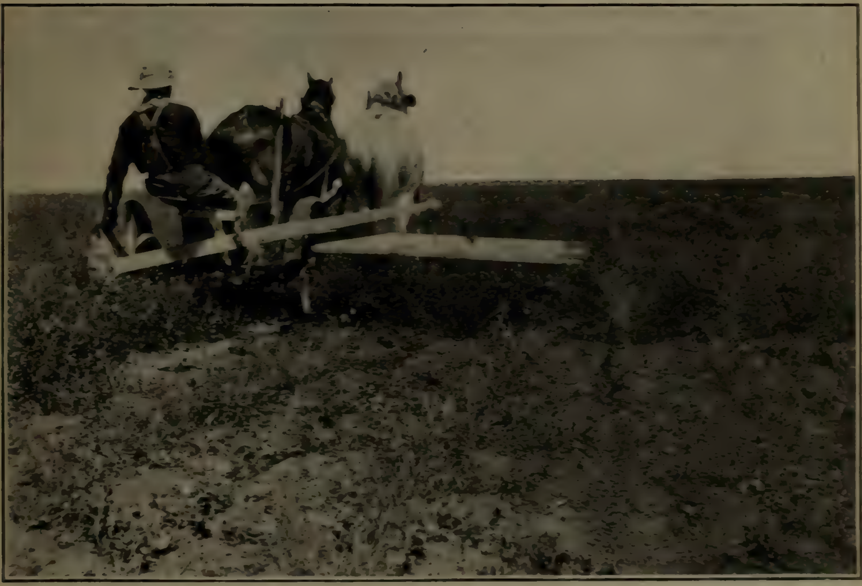


FIG. 10.—A mowing machine with dropper attachment in operation in a field of alfalfa in cultivated rows in western Nebraska. The rows in this case are one-half mile long.

---

[1] Farmers' Bulletin 421, entitled "Control of Blowing Soils," by E. E. Free and J. M. Westgate.

semiarid section in western Nebraska 16 months after seeding and which yielded a fair crop of seed.

During subsequent seasons little attention need be given the stand except the cultivations required to keep down the weeds and also to control properly the amount of moisture in the soil.

An ordinary corn cultivator with narrow shovels is adapted to this purpose. Very satisfactory results have also been obtained by the use of a spring-tooth harrow with some of the teeth removed so that the remaining teeth will work only the spaces between the rows.

If the plants tend to crowd each other as they become larger, cross-disking with the disks set to gouge as much as possible will assist in thinning out the plants. Cross-plowing may also prove advantageous if the use of the disk is difficult or ineffective. Where the area is not too large and plenty of labor is available a man with a grubbing hoe or mattock should be able to thin from half an acre to an acre a day if the plants are not too thick in the wide rows. This method would have the advantage of effecting the removal of the least desirable plants, leaving the rest thinned to the required intervals.

YIELDS OF ALFALFA SEED FROM CULTIVATED ROWS.

The practicability of growing alfalfa in cultivated rows for seed is to be determined in any given district by the increase in seed yield which can be obtained when compared with the yields either in thin broadcasted seedings or in narrow rows. The yield of hay possible when seeded in wide rows is usually about equal to that obtained from the broadcasted stands. For this reason the annual yield of seed is the deciding factor as to whether or not the increased expense of cultivating the alfalfa in rows is justified. Yields as high as 9 bushels to the acre have been obtained without irrigation in the semiarid sections from plants which had been specially selected for heavy seed production. Yields as high as 5 bushels to the acre are not uncommon.

In an experiment at Chico, Cal., under a single light irrigation, one-tenth of an acre in rows 4 feet apart, the third year from planting yielded at the rate of 458 pounds per acre, as compared with 215 pounds from the stands which were 2 years old.

ALFALFA IN CULTIVATED ROWS IN IRRIGATED SECTIONS.

The method of growing alfalfa in cultivated rows for seed was developed principally under dry-land conditions in the semiarid sections; but test plats have shown that increased yields of seed are possible even under irrigation, and for that reason it is suggested that this method be given at least a trial in the seed-producing irrigated sections of the country. The actual results obtained from row seedings as compared with broadcasted stands are shown on pages 10 and 24.

ALFALFA IN CULTIVATED ROWS IN SUBHUMID SECTIONS.

Tests of alfalfa in cultivated rows for seed-producing purposes have not been made in subhumid sections on a scale sufficiently large to warrant definite statements concerning its probable success. There are in many sections, however, areas of upland or thin, naturally dry soils which on account of their nature really present conditions of soil moisture comparable with the semiarid sections of the West. On such areas it is probable that the seeding of alfalfa in wide rows would be a practicable undertaking.

ALFALFA IN CULTIVATED ROWS IN SEMIARID SECTIONS.[1]

The special advantage of the semiarid sections for alfalfa-seed production lies in the fact that the conditions of relative drought during the seed-developing period combined with the high midsummer temperatures bring about an approach to the ideal conditions for the production of maximum crops of seed. By the cultivations rendered possible under such conditions the moisture supply in the soil can be regulated within certain limits and sufficiently conserved for the proper development of the plant and the production of profitable crops of seed. The general statements already made concerning alfalfa in cultivated rows will apply to the semiarid sections, but some attention must be given to the selection of the soils that will provide as nearly as possible the desired conditions of moisture during the growing seasons. In the very dry sections the lower lying soils must be utilized and it may even be desirable to select such soils as will receive a considerable portion of the run-off from adjoining areas.

When rains occur in the semiarid sections they are often too light or fall too fast to wet the ground to any considerable depth. Under such conditions the amount of moisture received into the ground is insufficient for best results from alfalfa even when utilized for a seed crop. Any method of handling the land that will tend to make it take up more of the rain water is desirable. If a nearly level field is available which can be made to receive the run-off water of a considerable area it may be practicable to open up surface ditches that will lead the run-off to this field, which should also be ditched to receive the water in event of rain. When the above suggestions can be carried out the efficiency of many of the rains could be greatly increased. It would be desirable, however, to provide for diverting the run-off flood waters when enough has run over the field.

---

[1] For a more detailed account of the growth of alfalfa in cultivated rows for seed production in semiarid sections, see Circular 24 of the Bureau of Plant Industry, entitled "Alfalfa in Cultivated Rows for Seed Production in Semiarid Regions," by Charles J. Brand and J. M. Westgate.

In the less dry sections the lands lying between the lower and the upland soils may be utilized for alfalfa-seed production. In the more moist portions of the semiarid regions and even in the subhumid sections the upland soils will more nearly provide the desired moisture conditions in an average season.

The preparation of the seed bed in semiarid sections also needs special attention, because it is usually necessary to conserve the moisture for some months or even a year or more in advance of seeding in order that an abundant supply may be available for the rapid early growth of the plants. Rapid early growth will enable them to compete with the drought-resisting weeds, which are quite certain to develop and cause trouble if the alfalfa plants are stunted by the lack of sufficient soil moisture during their first season of growth. This conservation of moisture is best brought about by surface tillage and proper packing of the subsoil.

ALFALFA SEED COMPARED WITH HAY AS A MONEY CROP.

It is seldom that any section grows alfalfa exclusively for the production of seed, although there are many sections in which it is utilized for hay only. Where a strong demand exists for alfalfa hay at good prices there is always the temptation to cut the crop for hay, as much less risk is then incurred and a very profitable return is ordinarily secured. The time required to develop a seed crop is at least twice that necessary for a crop of hay. Consequently two crops of hay must be sacrificed to produce one crop of seed and straw. The production of hay makes more profitable the utilization of the large outlying sections of summer-grazing land, from which cattle and sheep can be driven to the alfalfa stacks for winter feeding; but when for any reason it is difficult to dispose of the alfalfa hay, it then becomes advisable to give attention to seed production if it is at all feasible. In some of the more recently settled sections of the West more alfalfa hay has been produced than could be profitably utilized, owing to the shortage of stock to which it could be fed; neither could it be profitably shipped out, owing to the long railway-freight hauls. In other sections so far removed from the railroads that long hauls by teams are necessary, the production of alfalfa hay has been rendered much less profitable than it is in many other alfalfa sections. In such sections as those just mentioned the production of alfalfa seed offers special advantages, because the seed usually commands a good price and can be transported at a relatively small expense. At 12½ cents a pound a ton of alfalfa seed is worth $250 as compared with about $10 for a ton of hay. It is obvious that the product of an acre of alfalfa utilized for seed is much more easily transported than the product of an acre cut for hay. Furthermore, if the hay is sold from the farm a great deal of fertilizing material is removed and lost to the farm. When a seed crop is produced only a small amount of fertilizing material need be removed from the farm, since the straw or manure produced from it can be again returned to the land and plowed under.

Table III indicates in a general way the relative cost of production and returns from an acre of alfalfa left to stand for seed in comparison with the two cuttings of alfalfa hay which are ordinarily procurable in the same length of time. The figures given show that any excess over 200 pounds of seed produced will make the seed production correspondingly more profitable than hay. If the seed yield falls below 200 pounds per acre it becomes less profitable than the two hay crops, the returns from which vary but little. It will be noted that only the cost of the farm operations appear in this table, the rent of land, etc., being assumed to be the same in both cases.

Table III.—*Estimated relative returns from alfalfa hay crops and seed crop.*

Item.	Rate for single operation, per acre.	Cost of production and returns from an acre of alfalfa when utilized for—			
		Hay (two crops, 3 tons, at $10 a ton).		Seed (one crop, 200 pounds, at 12½ cents a pound).	
		Cost.	Return.	Cost.	Return.
Mowing	$0.50	$1.00		$0.50	
Raking	.20	.40			
Stacking	1.50	3.00		1.50	
Baling	3.00	6.00			
Thrashing	6.00			6.00	
Cleaning	2.00			2.00	
Hauling hay	2.25	4.50			
seed	.40			.40	
Total		14.90		10.40	
Value of product			$30.00		$25.00
Net profit per acre			15.10		14.60

ALFALFA SEED YIELDS.

The ordinary yield of an alfalfa field allowed to stand for seed ranges from 2 to 5 bushels per acre. Many yields run as low as 1 bushel per acre and even less, but yields of much less than 1 bushel are not usually considered worth thrashing or hulling. On the other hand, authentic records show rare instances when 18 to 20 bushels of clean seed have been obtained from an acre of ground. Such yields, however, are due to a very fortunate combination of circumstances which seldom recur in a particular community. In one rather large seed-producing locality the average for the entire section was over 10 bushels per acre the first year that seed was allowed to set on large areas. In the two years following these remarkable yields large acreages left standing for seed resulted in almost universal disappointment because the crop averaged probably less than a bushel per acre for the entire locality. Full seed crops are usually not to be expected until the third year, as the older alfalfa plants have deeper root systems which can utilize moisture and plant-food materials unavailable to younger plants.

CONTINUED CROPPING TO SEED AND ITS EFFECT ON ALFALFA PLANTS.

It is often considered much harder on the vitality of the alfalfa plant to produce a crop of seed than to produce a crop of hay, and for this reason some farmers hesitate to let a crop stand for seed every year, even when conditions are favorable for seed production. The data at hand, however, show instances of fields which have produced as high as five or six cuttings of seed in as many years and which are yielding just as satisfactory crops of hay as other near-by stands which have produced but one or two crops of seed during the same period. Individual plants as well as entire plats left standing for seed in experimental tracts have been observed to show a more vigorous growth the succeeding season than those cut throughout the season for hay. It would appear from the somewhat meager data that the one seed crop is even less injurious to the plants than the two cuttings of hay which would otherwise be removed during the same period of time. It is quite probable that the injurious effects which have been observed to follow heavy seed crops are not due primarily to the effect of the seed crop, but rather to drought or other conditions adverse to the vegetative growth of the plants and which induced the heavy production of seed.

DRAWBACKS TO THE SUCCESSFUL PRODUCTION OF ALFALFA SEED.

A very severe drought may prevent the plants from making sufficient growth to give much seed-producing surface or to fill the seed if they are set. A continued series of cloudy days, even though no rain may fall, may have an adverse effect on the setting of seed. The occurrence of continued cold weather will also seriously affect the setting of a good seed crop.

None of the disturbing factors noted are as a rule controllable, but strong individual development of the plant, such as is obtained in thin stands, tends to enable the plant to develop seed under somewhat adverse conditions and makes the limitations of seed production much less restricted than where the plants are crowded and strong development of the individual plants is prevented.

INSECT ENEMIES OF THE ALFALFA SEED CROP.

THE CLOVER-SEED CHALCIS FLY.

The clover-seed chalcis fly (*Bruchopaghus funebris* Howard), received its common name from the fact that it was first observed attacking the seed of red clover. It has, however, become of even greater importance as an enemy of alfalfa seed than it has of clover seed. In fact, it was in all probability originally introduced into this country from Europe or Asia in alfalfa seed. In distribution it covers almost if not quite the entire United States, occasionally becoming so numerous as practically to destroy the entire seed crop. This condition has been known to exist when the owner of the field did not even suspect the attack of insects of any kind. The egg of the chalcis fly is laid in the developing seed before it is hardened and while yet in an almost jellylike mass inclosed within a thin envelope. The larva developing from the egg feeds within this seed, which is incapable of supplying food for more than one individual. Passing its entire transformation from egg to adult within the seed, it makes its way forth precisely as in the case of red clover; that is, it eats a hole in one side of the seed and gnaws a corresponding hole in the pod through which it emerges. If the alfalfa is promptly thrashed the seed may still contain many of these insects which have not emerged from the seed. Later on these small black wasplike insects (fig. 11) may be seen crawling over the seed. Whether or not the insects are observed the small hole in the side of the seed or pod is an indication that they have been present. According to the observations of Roland McKee the damage can be reduced more or less by having the seed crop develop if possible at the time when there are fewest chalcis flies. This time can be determined in the different localities by noting the extent and time of maturity of their host plants. In sections where the bur clovers (*Medicago* spp.) are common the chalcis is most abundant at the time of maturing of the seed of this crop and the damage to alfalfa seed maturing at the same time or soon after is great. In sections where bur clovers are not common the wild clovers (*Trifolium* spp.) and alfalfa in waste places afford the most common

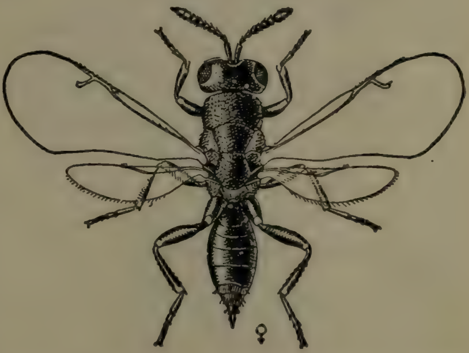


FIG. 11.—Adult form of the clover-seed chalcis fly (*Bruchophagus funebris*) after emerging from an alfalfa seed. The wings ordinarily are closely folded along the back. (Greatly enlarged.)

breeding places. By keeping the alfalfa cut from the roadsides, along fences, and in other waste places where it ordinarily seeds undisturbed, the number of chalcis flies will at least be reduced. In most localities outside of the bur-clover districts the earlier in the season an alfalfa seed crop can be harvested the less will be the damage. In southern localities the earliest bloom produces little seed. This insect is more fully discussed in Circular 69 of the Bureau of Entomology, United States Department of Agriculture.

GRASSHOPPERS.

Many species of grasshoppers attack and do serious injury to alfalfa throughout almost the entire region of its cultivation. Perhaps the yellow-winged locust, *Camnula pellucida* Scudder, is the most common depredator in the West. The eggs of grasshoppers are laid in the ground in late summer in podlike sacks. They are deposited almost entirely in uncultivated lands. These eggs hatch the following May or June and in about a month the young grasshoppers become fully developed and winged so that they can migrate.

There are two popular methods of destroying these insects. One method is to collect them in shallow pans known as hopperdozers. The other method is to use poisoned baits. The most effective bait is known as the Criddle mixture, composed of 1 pound of Paris green, or some other convenient arsenical, and 2 pounds of salt thoroughly mixed with 60 pounds of fresh horse droppings. This bait is scattered among the young insects or around the edges of fields which it is thought may be invaded. A very convenient receptacle in which to make this preparation is a barrel cut in half. A trowel or paddle can be used in scattering the mixture where desired. Another poison mixture is composed of 1 pound of Paris green to 50 pounds of bran moistened to a stiff dough with sweetened water. Either of these poisons scattered among grasshoppers proves a very attractive bait and effectually disposes of any grasshoppers partaking thereof.

THE ALFALFA CATERPILLAR.

The larvæ or caterpillars of a very common yellow and black butterfly (*Eurymus eurytheme* Boisd.) occasionally become excessively abundant especially in the southwestern portion of the country, effectually destroying not only the first cutting but succeeding cuttings also, thus making the production of seed impossible. The results of investigations which have been carried on by the Bureau of Entomology (see Circular No. 133) seem to indicate that a larger part of the damage can be prevented by cutting the alfalfa at a time when the caterpillars are young and thus deprive them of their food supply, which results in their death. In irrigated sections the water should be applied as soon after cutting the hay crop as possible.

THE ALFALFA WEEVIL.

The insect known as the alfalfa weevil (*Phytonomus posticus* Gyll.) is about the size of a grain of wheat, brown in color, with a long slender snout, much like the plum curculio. Imported from the Eastern Hemisphere it has become established in the region of country near Great Salt Lake, Utah, whence it has spread into southern Idaho and western Wyoming. It has proved a most destructive pest of alfalfa and the production of seed has been impossible in the localities where it has occurred. (Fig. 12.) It is being investigated in order to find some means of preventing or reducing its ravages. These measures have consisted of the application of mechanical devices for destroying the young weevils in the fields, destroying the adults in their hibernating places, and the introduction of its natural enemies into this country from Europe, where they seem to effectually prevent serious injuries from its attacks on alfalfa. A more detailed account is given in Bulletin 112 of the Bureau of Entomology, United States Department of Agriculture, entitled "Preliminary Report on the Alfalfa Weevil," by F. M. Webster.

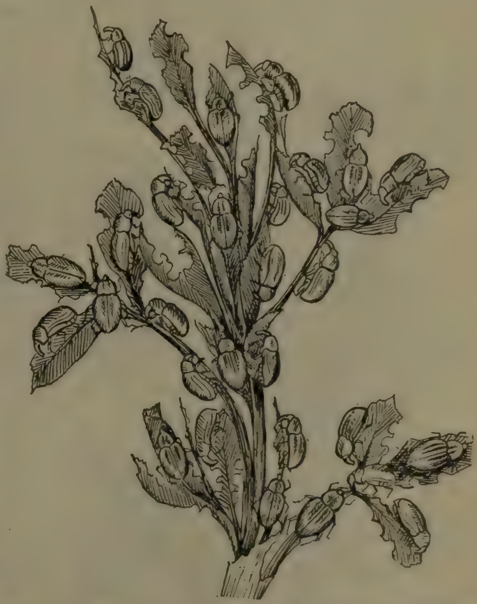


FIG. 12.—Adult form of the alfalfa weevil (*Phytonomus posticus*): Adults clustering on and attacking a spray of alfalfa. (Slightly enlarged.)

WEEDS AFFECTING THE ALFALFA SEED CROP.

Weeds constitute a rather serious menace to the successful production of alfalfa seed. They not only crowd the plants in the field but their seeds are harvested with the alfalfa seed and are thus often sold with it and carried to other sections. In this way they spread with possible damage to the farms on which the seed is sown.

The problem of weed destruction in alfalfa stands is difficult. Alfalfa is less aggressive than many weeds. The alfalfa plants do not spread by runners or rootstocks as do many of the grasses, while old alfalfa stands ordinarily do not thicken up from self-sown seed, as is the case with most of the weeds. The weeds in an alfalfa field tend to increase more rapidly when the stand is allowed to remain for seed each year than when the field is mown regularly for hay. When this weedy condition develops, a year or two of regular mowing for hay will do much toward reducing the number of weeds present in the field.

The dodders or "love vines" (*Cuscuta* spp.) are among the worst weeds with which the alfalfa plant must contend. The dodder seed is often introduced into the alfalfa field with the original seeding. The seed of the large-seeded dodder is so nearly the same size as the alfalfa seed that it is almost impossible to screen it all out, even with the most carefully constructed sieves. The dodder plant itself is a yellow threadlike vine which attaches itself to the alfalfa plant. (Fig. 13.) It often destroys the seed-producing capacity of the plant which it attacks and matures its seed so as to be harvested with the alfalfa seed.[1]

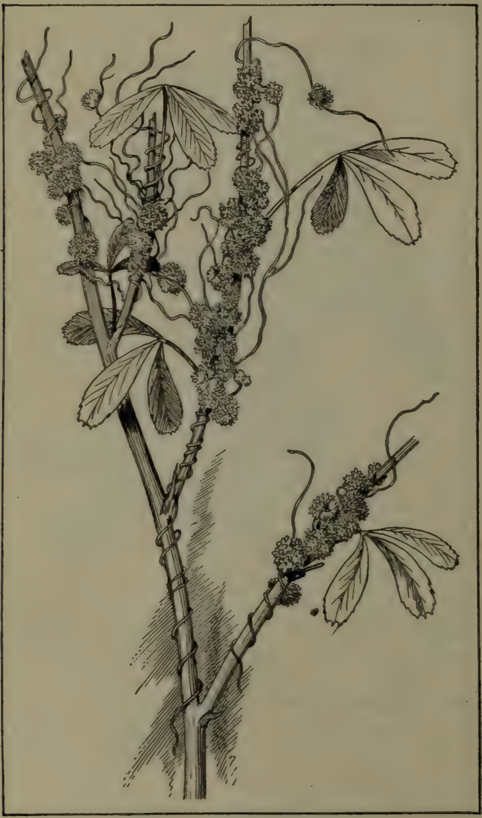


FIG. 13.—A mature dodder plant on an alfalfa stem.

The wild barleys (*Hordeum* spp.), often called foxtail in the Western States, seriously affect the first cutting of alfalfa, but since these weeds grow principally in the cooler portions of the year they affect the seed production only indirectly. The true foxtails (*Chaetochloa* spp.) and crab-grass (*Syntherisma sanguinalis* (L.) Dulac) prove troublesome in the subhumid sections, as in central Kansas, while the Russian thistle (*Salsola kali rosacea* Pall.) is at times very troublesome in the semiarid sections, especially in thin stands or where the alfalfa is being grown in wide cultivated rows. The Russian thistle seeds are with difficulty removed from the alfalfa seed, although some of the seed-cleaning devices founded on the inclined canvas roller system are said to be efficient in removing them. They are about the same size as the alfalfa seed but of different shape. (Fig. 14.)

---

[1] See Farmers' Bulletin 306, entitled, "Dodder in Its Relation to Farm Seeds," by F. H. Hillman.

In most of the Rocky Mountain seed-growing sections wild mustard (*Brassica* sp.), the cheat grasses (*Bromus sterilis* L. and *B. secalinus* L.), and sweet clovers (*Melilotus alba* Desr. and *M. officinalis* (L.) Desr.) are quite troublesome. Star thistle (*Centaurea solstitialis* L.) is more or less troublesome in the alfalfa seed-growing sections of the Southwestern States, but its seeds are less difficult to separate from alfalfa seed than those of the other weeds mentioned, and therefore its menace is less serious.

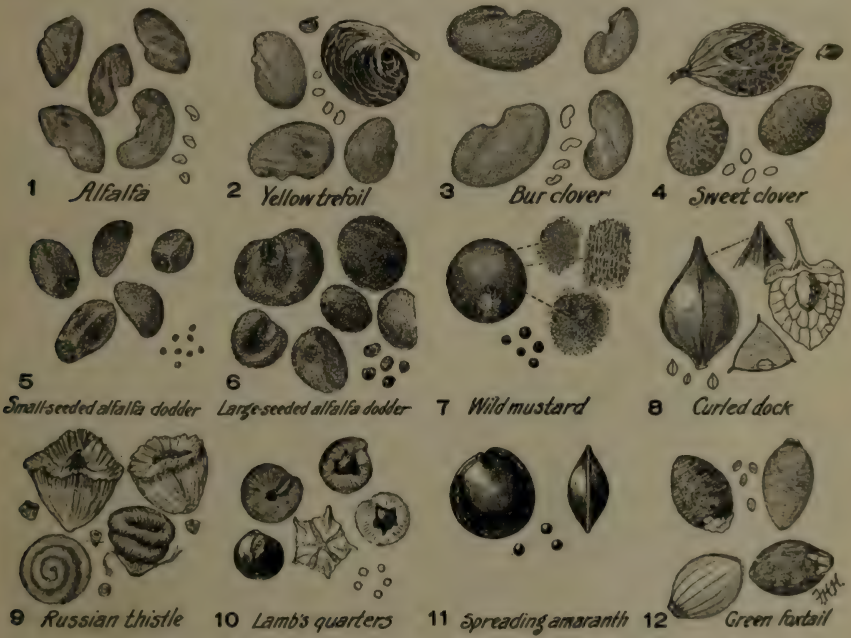


FIG. 14.—Seeds of alfalfa and common adulterants and impurities. (Enlarged and natural size.)

ADULTERATION OF ALFALFA SEED.

After alfalfa seed leaves the farm and enters the market it is sometimes adulterated by unscrupulous dealers with other less valuable seeds closely resembling alfalfa. Bur clover and yellow trefoil are the principal adulterants. When buying alfalfa for seeding it is important to examine the seed for such adulterants, as well as for other weed-seed impurities. This precaution is of special importance when the prospective planting is to be utilized for seed production. The methods of testing alfalfa seed for adulterants and impurities as well as for germination are fully discussed in other Farmers' Bulletins.[1]

---

[1] See Farmers' Bulletin 194, entitled "Alfalfa Seed," by Edgar Brown, and Farmers' Bulletin 428, entitled "Testing Farm Seeds in the Home and in the Rural School," by F. H. Hillman.

LONGEVITY OF ALFALFA SEED.

Alfalfa seed retains its vitality for a comparatively long time. Seed 2 or 3 years old is practically as good for planting as fresh seed. This makes it possible to carry the seed over a year or more in case it should become necessary. The results of germination tests are given in Table IV, in which the percentage of good seed shown includes the "hard seed" as well as that which germinates readily.[1] The seed upon which the tests were made was obtained from various sources and no doubt varied somewhat in the quality of the original samples. This fact together with the comparatively small number of tests made tends to explain the lack of a uniform deterioration of vitality as age increases.

TABLE IV.—*Percentage of good alfalfa seed at different ages.*

Item.	Age of seed in years.									
	1	2	3	4	5	6	7	8	9	10
Number of tests	5	7	4	11	9	8	7	5	5	5
Percentage of good seed	93	84	79	63	68	71	48	41	65	44

COMMERCIAL ASPECTS OF ALFALFA SEED PRODUCTION.

In addition to the statements already made concerning the greater ease of marketing alfalfa seed than of marketing alfalfa hay, owing to its much less bulk for a given value, other important commercial aspects deserve consideration. Among these problems is that of suitably cleaning the seed so that it will command good prices when it reaches the distributing centers. The seed of any one community is usually bulked before shipping to the distributing centers, and unfortunately the grade of seed is often determined by the presence of a few poor lots of seed among those of higher grade. For this reason it is very important that the seed of any given section be reduced as nearly as possible to a uniform basis before entering the ordinary channels of trade. At present this is done to a certain extent by local merchants, some of whom install machines with which they clean the seed either before or after purchasing it from the individual farmers. It is suggested that a cooperative arrangement among different farmers might result in a more satisfactory solution of these somewhat difficult problems of hulling, cleaning, and marketing the seed. With cooperation once started it need not be confined to cleaning and marketing the seed crop to the best advantage, but might be extended to the undertaking of cooperative experiments on the individual farms to determine the best of several possible methods of handling the seed crop in their particular section. With a number of farmers trying different treatments on their fields, experience could be obtained in one season which would otherwise require a number of years to procure. This plan of cooperation could also be utilized in the establishment of some trade variety of seed. A premium could be commanded for such seed if it was of good quality, and especially if of a variety in strong demand in some particular section of the country. The extreme northern seed-producing sections might take up the production of a hardy strain such as the Grimm alfalfa, an unusually hardy variety which has been grown for over fifty years in the severe winter climate of Minnesota. The demand for this variety will for years probably far exceed the supply. Farmers located in the southwestern part of the country with equal advantage might undertake the production of the Peruvian alfalfa seed, which is obtained only in very small quantities and with great difficulty in South America. When once established this variety produces satisfactory seed crops in the milder sections of California and Arizona. In the same manner farmers in the semiarid sections could determine by preliminary experiments the most valuable strain for their sections of the country and could then develop this strain so that it would have a recognized superior value on the market. Since large quantities of seed are annually imported to meet the increasing demand it is probable that it will be some years before the home-grown supply will equal the demand.

---

[1] See footnote on page 14.

The lowest price of the season usually prevails shortly after the hulling season is over. Better prices could be obtained if means were at hand for holding the seed until the desired price was secured. If a cooperative association were organized in a proper manner, each member could store his seed in the association's warehouse and, if desired, receive an advance of at least two-thirds the market value of his seed in cash at a nominal rate of interest pending the time he decided to sell his seed.

SUMMARY.

The increasing demand for alfalfa seed has not been entirely met by the home-grown supply; as a result, large quantities of seed are annually imported. It is entirely possible for the American farmer to produce all the seed required for use in this country, but the many uncertainties in connection with the production of the seed crop have often deterred growers from letting their fields stand for seed. The principal alfalfa seed-producing sections are those where a relative shortage of water exists during the time that the seed crop is maturing and where the temperatures at this time are comparatively high. Profitable seed crops are produced in the subhumid and semiarid sections of the Great Plains area without irrigation and in the semiarid and arid districts farther west either with subirrigation or partial surface irrigation. Seed production in rows is giving promise of success. It is of utmost importance in all sections that the stand should be thin. The extremely large yields of alfalfa seed produced under specially favorable conditions not generally understood or even recognized indicate the possibilities in connection with seed production when the conditions favoring maximum seed crops are fully realized.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

○

RAISING BELGIAN HARES AND OTHER RABBITS

DAVID E. LANTZ

Assistant Biologist

SUPERSEDED BY 1090

FARMERS' BULLETIN 496

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Biological Survey

E. W. NELSON, Chief

Washington, D. C. Issued May 7, 1912; revised August, 1917

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

[illegible]

THE present shortage of farm live stock throughout the country is one that can not be remedied quickly. In the Belgian hare and other domesticated rabbits we have animals that breed rapidly, mature early, and furnish a palatable and highly nutritious meat. The supply can be increased enormously within a few months, without using space that may be needed for the production of crops. Rabbit meat can be produced in almost unlimited quantities at a less cost than that of any other meat, not excepting poultry.

The business of growing rabbits on farms and on village lots affords opportunity for an agreeable change in the family diet, for cutting down the cost of living, and for conserving the meat supply of the country. Though not always yielding large profits, it is a reasonably remunerative adjunct to other pursuits; and, with a favorable market, may be expanded into a commercially successful vocation. It is especially suited to young people. It is hoped that the present bulletin may be helpful to many who will engage in a work that should be of great importance at this time, especially if the rabbits are grown for home use.

RAISING BELGIAN HARES AND OTHER RABBITS.

CONTENTS.

	Page.		Page.
Rabbits as food	3	Breeding	10
History and characteristics of the Belgian hare	3	Marketing	12
Selection of stock	5	Cooking and serving	14
Hutches and pens	6	Rabbit skins	14
Food and feeding	9	Ailments of rabbits	15
		Literature about rabbits	16

RABBITS AS FOOD.

IN the United States wild rabbits always have been an important source of food, especially during the cold part of the year, and hence less attention has been paid to the breeding of rabbits than in most foreign countries. It would be impossible to estimate correctly the number of rabbits marketed and eaten in Great Britain. Before the present war not only were the home warrens and farms drawn upon for a supply, but from 10,000 to 12,000 tons were imported annually, partly from the Continent, but in greatest numbers from Australia and New Zealand. In France, Holland, and Belgium rabbits were a common article of diet, and rabbit breeding was general, especially on the smaller farms. Spain produces many domestic rabbits and is sometimes regarded as the original home of the common European rabbit. The so-called Belgian hare is merely a domesticated form of the wild rabbit of Europe, long bred with special reference to the development of a superior food animal. Its flesh is generally considered better than that of the ordinary hutch rabbit.

The Belgian hare is one of the best rabbits for table use. It weighs more than most breeds, develops very rapidly, and the quality of the meat is superior to all the others. The Flemish giant is a cross between the Belgian hare and other breeds, developed especially for large size, with the result that the flesh may be slightly coarser in mature animals. With young hutch rabbits, few persons can distinguish differences in the quality of the flesh of the various breeds. Much of the excellence of the rabbit as food depends on the rapidity of its growth and still more on the manner of cooking it. As often prepared, it is dry and insipid; but in the hands of an experienced cook it becomes all that the most fastidious taste can wish. An especial requirement in cooking the Belgian hare is that none of the natural juices of the meat be lost in the process.

HISTORY AND CHARACTERISTICS OF THE BELGIAN HARE.

The Belgian hare probably originated in Belgium or northern France. It was known very generally in the northern part of Continental Europe before the attention of English fanciers was directed to it. As their first stock came from Belgium, that country was credited with having originated the breed. The chief known reason for calling the animal a hare lies in its resemblance in color to the wild hare (see illustration on title page).

In the hands of English fanciers the Belgian hare was improved greatly. The English standard for the breed was adopted in 1889, and a few years later standard-bred animals were brought to America, where they soon became exceedingly popular. The finest show animals often commanded very high prices, and extraordinary claims were made concerning the excellence of the breed for the table. As was natural, when the reaction came and the public learned that the Belgian hare is a rabbit not vastly superior to other breeds, the animal was unjustly condemned and fell into disfavor. As a consequence, the whole business of breeding domestic rabbits in the United States was for a time neglected.

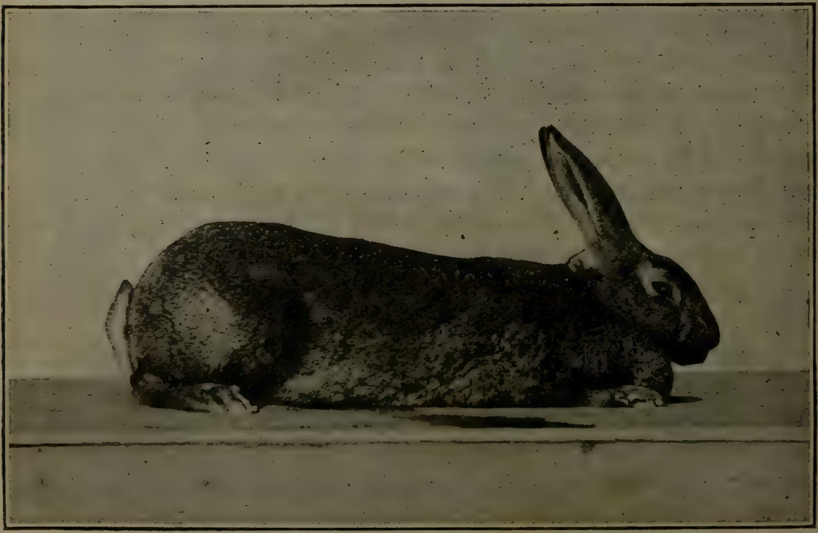


FIG. 1.—Female Flemish giant.

In spite of the setback caused by the collapse of the Belgian-hare bubble, this breed has maintained a greater popularity than any other, and many breeders are still raising and improving it. The Flemish giant (fig. 1), owing to its greater size, is preferred by some. The fact that rabbits are easily grown and are a cheap and excellent substitute for the ordinary meats is likely to turn the attention of many more persons to rearing the animals. That they can be propagated without costly investment in land and buildings is a peculiar advantage. Further, the presence on the farm of another animal which, like poultry, may be killed and prepared for the table entire and at short notice, is exceedingly desirable.

CARE OF OTHER BREEDS OF RABBITS.

The directions herein given for the care of Belgian rabbits are applicable to the management of most other breeds. The ordinary English rabbit, regarded as of less value as a food animal, is even more hardy and therefore needs less care. The lop-eared rabbits and possibly a few other breeds require artificially heated quarters in winter, but in other respects their management is the same as for the Belgians.

SELECTION OF STOCK.

If rabbits are bred for food only, the selection of stock is of less importance than when they are bred for show purposes. All that is required is a sizable animal of good, hardy stock. However, the points for which the fancier breeds the Belgian hare include also those most desirable in a food animal, so that if one can find stock with these characters well marked, and at the same time constitutionally sound, he should by all means obtain it. Pure-bred stock is more profitable, too, because it may be sold for breeding purposes as well as for the table.

GENERAL STANDARDS.

Color.—Belgian hare fanciers of a few years ago differed somewhat in opinion as to the proper standard of color for this animal. Some aimed at the color of the wild English hare—a sandy light brown. Most American breeders seem to have preferred a deeper reddish brown. In all other respects the standards were the same. The chief requisite concerning color is that it shall be as nearly uniform as possible throughout the upper surface of the animal and that the fur shall have a rich luster. The "ticking," or shading, should be wavy rather than dotted. The belly and the lower surface of tail and hind feet should be whitish, but not pure white. The neck and breast should be somewhat lighter in shade than the back, but not in marked contrast with it, nor should the change in shade be abrupt.

Ears.—The ears of the mature Belgian should be about 5 to 5½ inches in length, varying with the size of the animal. They should be well shaped, strong at the base, and almost transparent at the middle. They must not be pendulous, but should, when the animal is quiet, be inclined backward, resting straight over the shoulders. A narrow black edging at the tip and as far down the front and back as possible marks the best stock.

Body.—The body of the Belgian is longer in proportion to the whole bulk than that of any other breed of the same size. Bucks and the younger females should never have the appendage known as "dewlap." This sometimes develops in the older does, but is regarded as a blemish in animals intended for show purposes. The back should be only slightly arched, and the forelegs and feet should be perfectly straight and free from white.

Age of breeding stock.—The beginner should always select mature animals about a year old for breeding stock. These may be known by the brisk, alert look, the small white teeth, and the small claws, almost hidden in the fur. Coarse, long claws are a sure indication of age. Listless-looking, rough-coated, or pot-bellied animals (except pregnant does) should be rejected, especially those having the whites of the eyes stained with yellow. A hutch rabbit in good health is gentle, neither savage nor overtimid, and does not scream when lifted by the ears.

The sexes.—The does selected for breeding may be of the same strain and even of the same litter, but the buck should be of different stock, and when possible obtained from another breeder. Hardy young animals with the best characteristics of the breed may be bought at from $1 to $2 each. Often they may be had of near-by breeders, thus saving the expense of carriage on long journeys by express.

HUTCHES AND PENS.

The Belgian hare does not do well when kept wild in open warrens. The common English rabbit is better for this purpose. A good many Belgians have been turned out in various parts of the United States, and in the vicinity of the city of New York and on the western coast this has resulted in some complaints of damage to crops. As a rule, however, and fortunately for the farmer, these animals, when obliged to shift for themselves, fall an easy prey to their enemies and disappear within a few months.

Belgian hares may be managed successfully in two ways: (1) Entirely in hutches, or (2) in outdoor fenced runs, or courts, with hutches for does when having young, and sleeping hutches for other stock. The hutch system with various modifications is the more common and is the only method adopted by rabbit fanciers who raise for show. The use of small runs or rabbit courts to give the animals healthful exercise in fine weather is of advantage.

THE RABBITRY.

The rabbitry may occupy part or all of a barn or shed, or be built in a sheltered space in the angle between buildings or walls. The indoor rabbitry has decided advantages. The place should be well ventilated, but not subject to drafts of cold or damp air. These may be prevented by ventilators in the roof, or by a system of elbowed pipes passing through the sides of the building and reaching a height of 2 or 3 feet above the openings.

HUTCHES.

Hutches for the Belgian hare should be somewhat larger than those intended for smaller breeds. They should be built of good lumber, have tight floors, and have at least 12 square feet of floor space and a height of 2 feet. If there is plenty of room in the rabbitry it is best to have the hutches separate; but they are usually set in tiers or stacks, two or three in height. Each hutch in the rank is complete in itself, so that its position may be shifted at any time.

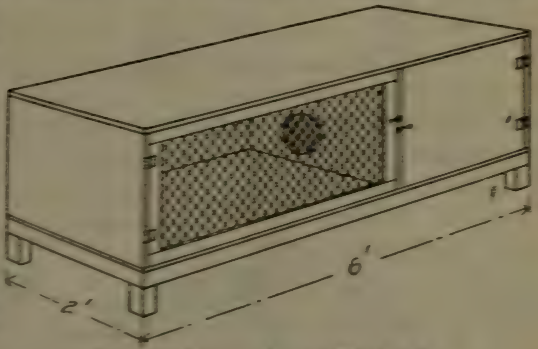


FIG. 2.—A convenient rabbit hutch.

A convenient indoor hutch (fig. 2) is one 6 by 2 by 2 feet, with a movable partition dividing off a third of the space at one end for a nest and sleeping chamber. The partition has a smooth hole to permit passage of the animals from one part to the other. The front of the hutch has two doors, one of wire netting, the other of wood. The wooden door opens to the sleeping chamber and should close tightly. It is best to use metal hinges for the doors. The partition may slide in a groove between the doors or may be put in and taken out through one of the door openings.

Outdoor hutches should have sloping roofs and overhanging eaves to protect them from rain. The screened door should have a sliding cover of wood or be fitted with a removable cloth cover. Small holes bored near the top of the hutch will afford all necessary ventilation.

Movable hutches (fig. 3) have some advantages. They may be carried outdoors in fine weather and taken back under shelter at night or during storms. Long, narrow cleats projecting at both ends of the hutch are all that are needed to convert the ordinary hutch into a movable one. Two forms of outdoor hutch sometimes used are shown in figures 4 and 5. That in figure 4 has no floor except a wire screen, permitting the rabbits to eat grass or other herbage that projects through the netting.

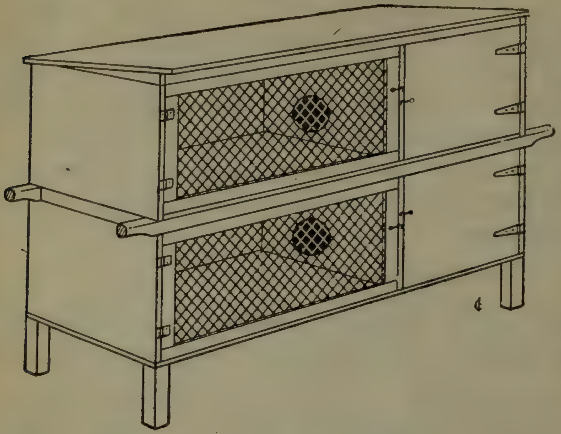


FIG. 3.—Movable outdoor hutch.

COURTS.

A rabbit court may be paved or floored, or it may be a grass court surrounded by a rabbit-proof fence. Sleeping hutches inside the court may be small boxes of any sort if they are stout and waterproof. They should have sliding doors to confine the rabbits if desired, and should also have small holes near the top for ventilation. If a court is used, hutches will still be needed for the breeding does.

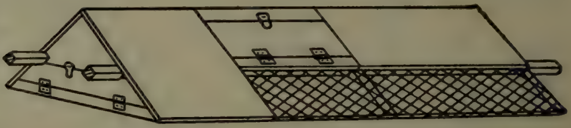


FIG. 4.—A simple movable outdoor hutch.

A rabbit-proof fence to inclose a grass court should be made of heavy poultry netting 5 or 6 feet wide and of 1½-inch mesh. The posts, projecting 3 or 4 feet above the ground, should be well set outside the edge of the court. The netting is stapled to the posts, leaving a projection of 6 inches or more at the top and about 18 inches at the ground, to be turned into the court. The lower edge should be covered with 10 or 12 inches of soil to prevent the animals from digging out. The upper edge also is turned inward to keep them from climbing over. Brackets at the tops of the posts make the best support for the overhanging netting, although horizontal pieces of wood nailed to the posts will answer.

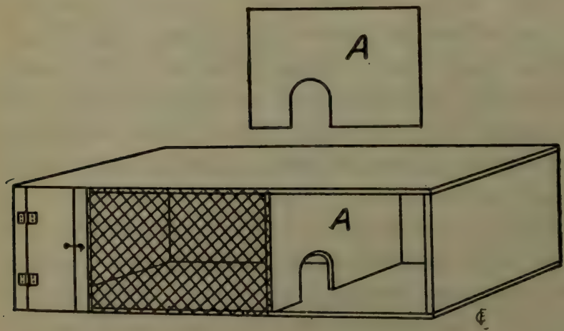


FIG. 5.—A simple outdoor hutch.

FOOD AND FEEDING.

The rabbit thrives well on a diversity of vegetable foods. Many writers on the care of this animal prescribe elaborate lists of foods to be followed week in and out. The fact is that a few staple foods are sufficient, but no animal is more adaptable to sudden changes of diet; so that one can feed what is available or cheap, the idea being to produce weight with the least possible outlay of money.

GRAIN AND HAY.

The best grain for rabbits is oats, either whole or crushed, though corn meal, barley, or other grain may often be fed by way of change. The crushed oats are best when freshly broken, and a hand mill for preparing them is a valuable adjunct to a rabbitry.

Hay is a necessary part of the rabbit's diet, and if possible that of the very best quality should be used. It should be entirely free from moldiness, and the unsweated is always preferable. If one has small grounds where suitable grass grows, the mowing may be done at short intervals and the hay thoroughly cured in such small quantities that no sweating takes place. However, if sweet hay is not available the sweated may be fed to the rabbits without injury, unless it be moldy.

GREEN FOODS.

Rabbits require some green foods for winter. Cabbages, kale, spinach, and rape leaves are recommended. Turnips, beets, and mangels are often fed and have been recommended by many rabbit breeders, but they do not keep so well as the foods just named. Turnips, unless kept in the ground, wilt by midwinter and are then of little use. Beets and mangels keep better, and the latter are the main dependence of some English rabbitries; but, on the whole, cabbages are more economical, as well as more satisfactory in every way. They are usually available until green stuff grows in the spring. Whatever green food is put away for winter use must be stored where frost can not touch it, as freezing unfits it for rabbits. Parsnips left in the ground all winter make an excellent early spring rabbit food after the frost leaves the ground in which they grow.

FEEDING.

Rabbits should be fed twice daily. Ordinary stock is fed morning and evening, but suckling does should also have a noon meal or be given more than they will eat at the other meals. The general rule is to feed only as much grain or green stuff as the animals will consume. Hay is put into the hutch to be available at any time, a part of it being left as litter. The exact amount of grain or green stuff for each rabbit at a meal can not be stated, as the appetite varies greatly at different times. Observations of the quantity left over when the animals quit feeding will soon enable the feeder to adjust the meals to the needs of the rabbits. Overfeeding is a much more common mistake than underfeeding.

Winter feeding.—In winter one of the meals each day should be chiefly of green food (as roots or cabbage) and the other mainly of grain. Roots, cabbage, celery, and the like should be washed clean of soil, but should not be wet when given to the rabbits. If green food is given in the morning, the evening meal should be whole oats or other grain for mature animals. Those under 3 months of age should be given crushed oats with a little bran, as they can not so well masticate whole grain. A little hay should be given with each meal.

Summer feeding.—In summer green food should be the chief reliance, and only a small quantity of hay or grain is needed. Rabbits are fond of all kinds of garden vegetables, besides wild parsley, dandelion, plantain, dock, and other weeds, as well as lawn clippings and other grasses. Agreeable changes in diet are always possible in summer, but overfeeding should be avoided and also the feeding of stuff that is wet with dew or rain. It is best to cut clover or other green food in the afternoon before the dew falls and to spread it under shelter, so that it will not heat, but be still fresh at feeding time.

Corrective feeding.—Occasionally a warm mash of cooked potatoes or of the leaves of clover hay mixed with "chops" or a little bran is desirable. Sometimes a little sulphur may be sprinkled with the mash, although a little flour mixed with the ordinary grain has about as good an effect in correcting looseness of the bowels. In cold weather some breeders feed a warm mash each evening.

Unless green food is abundant rabbits should be given water daily. In warm weather the water pans should be filled with fresh water twice each day. The does suckling young or soon to have young should be given milk diluted with one-third warm water.

A piece of rock salt kept in each hutch affords a steady supply as needed and makes it unnecessary to supply salt in the food.

Rabbits under 3 or 4 months old should be limited in the amount of green food. If allowed too much they are apt to become "pot-bellied." When a young rabbit is seen to grow big about its belly, the use of green food should be discontinued and the animal given plenty of exercise. Under such treatment it will soon recover, but if the green food is continued the disease usually terminates in convulsions and death. Old rabbits are not subject to this trouble.

BREEDING.

It is not desirable to pair rabbits until they are at least 6 months old, although they may be bred earlier. Some breeders do not mate animals under 10 months of age. Healthy mature rabbits produce larger and stronger litters than younger stock do.

METHODS OF MATING.

Different breeders adopt different methods of mating. Some leave the buck in the hutch of the doe for but a few minutes, and others leave him overnight. The older does should be mated in February, but it is well to defer mating a young doe until March. She then has young in April, when there is abundant green food to induce a good flow of milk. This lacteal development once well established, she is likely always to give abundance of milk for her young. If pairing begins in February each doe may be expected to produce four litters a year, the young coming at intervals of about 12 weeks, with a longer rest in midwinter.

PREPARING FOR THE YOUNG.

The gestation period of the rabbit is about 30 days. When the doe is nearly ready to bear young, her hutch should be thoroughly cleaned and disinfected, after which a good supply of soft hay or straw (oat straw is best) should be placed in the body of the hutch to enable her to arrange her nest. If the hutch is without a nesting compartment, a box should be placed in a corner. It should be 18 to 20 inches long, about a foot deep, 8 or 10 inches wide, and without a lid. Make a hole in one end large enough for the doe to pass through easily, and turn the box upside down. The doe will arrange her nest a day or two before the young are born. At this time extra attention should be given to her food. She should have milk and warm water regularly, and a pan of clean water should be kept constantly in the hutch. While a doe is heavy with young and for a few days after their birth, extreme care should be taken to see that she is not frightened by cats or dogs or even by strange visitors in the rabbitry. Avoid touching the nest or handling the young, unless it is absolutely necessary.

DIET WHILE NURSING.

During the first week or two after having young the doe may be fed almost entirely on warm milk and bread. This is recommended for the bulk of the morning and evening meals, with a small supply of green food. Green food may be given also in the middle of the day, and the daily proportion gradually increased. Boiled mush made of corn meal is also an excellent food for suckling does, but most other pasty or watery foods should be avoided as likely to derange the bowels. Milk, and indeed any soft food, should be fed in a separate earthenware dish, especially in warm weather, when it sours quickly. The dish should be washed and scalded often.

NUMBER OF YOUNG.

The number of young produced by the Belgian hare varies greatly. Litters of 10 or 12 occur, but these are too large for a doe to raise. An average of 6 or 7 is all that should be saved. It is of advantage to have several does breed at about the same time, for the number of young may then be adjusted by transferring from those that have too many to those having few. The young begin to leave the nest when about 3 weeks old. At this time the nesting box or compartments should be thoroughly cleaned and disinfected and then furnished with fresh straw or hay.

WEANING.

The young may be weaned when a month old, but it is better to leave them with the doe two or three weeks longer. Remove two each day until all are transferred to another hutch, which may be large enough to accommodate any number. They do well together until they are 3 or 4 months old, when their development will compel separation of the sexes. After this any number of does may occupy the same hutch, but bucks, unless thoroughly accustomed to each other, will fight.

MARKETING.

At 4 months the young Belgian hare should be ready for the table, and if it has been properly fed should weigh about 6 pounds or even more. This weight is about the best for market rabbits, and immediate sale is more profitable than keeping to maturity. Some breeders sell at 10 to 12 weeks and aim to have their stock weigh about 5½ pounds at that age. To do this requires that the animals be kept in small hutches where they can have but little exercise and that they be fed heavily from the time they are weaned. Under this treatment they grow very rapidly and are really superior for the table.

MARKET RETURNS.

It is not easy to state what a breeder should realize for market rabbits. Much depends on local conditions and especially upon the familiarity of the public with the excellence of hutch rabbits for the table. If the animals are new to a market, a demand for them will have to be built up, but as a rule they soon will become popular. Better prices usually can be had by selling directly to the consumer, thus saving the middleman's profit. One may make arrangements to deliver regularly or periodically to hotels and restaurants, but often a poultry dealer will agree to take a certain quantity at regular intervals. If members of the family look after the rabbits, so that there is no outlay for labor, and if the hutches are built at home, the cost of rearing may be greatly reduced and much of the income will be net gain. Although it must be admitted that rabbits require more care than usually is given to poultry on our farms, their management has the advantage that it is more interesting, especially to the younger members of the family.

DISPOSING OF SURPLUS.

After selecting the best stock for breeding purposes it is well to dispose of the remainder as rapidly as conditions warrant. If those to be sold are to be marketed alive all that is needed is to crate them properly and forward them to their destination. This is the better plan in hot weather, as the carcasses do not keep well. If carcasses are to be delivered the methods of killing and packing are important considerations.

KILLING.

There are two excellent ways of killing the animals. The easier and probably the more humane is to dislocate the neck. Almost all gamekeepers know this method and can show the novice quickly how it is done, but probably a description will be understood. Take the two hind legs of the rabbit firmly in the left hand, place the thumb of the right hand just behind the ears where the neck joins the skull, the palm resting on the left side of the face and the fingers holding firmly under the jaws. Then stretch out the animal quickly and with force, pressing in the right thumb and bending the head backward. The dislocation will be felt distinctly. This method requires considerable strength, but when the knack of it is learned it entails less suffering than any other. Another excellent way of killing is to hold the rabbit up in the left hand, as in the first method, and then to strike a sharp blow on the back of the head with a round stick, stunning the animal. As soon as the neck is dislocated or the rabbit stunned the jugular vein should be cut with a sharp knife and the animal hung head downward to bleed.

DRESSING.

The next step in preparing a carcass for market is to remove the paunch and entrails, as their presence would soon taint the meat. With a sharp-pointed knife make a longitudinal cut down the middle of the belly, dividing the skin and the thin abdominal walls, but being careful not to cut the intestines. Turn out the paunch and the intestines, but leave the lungs, liver, heart, and kidneys in place. Next make a slit between the large tendon and the bone of one hind leg and slip the other leg through the cut, so that the carcass may be readily hung up. It should hang long enough to stiffen before being packed.

PACKING.

For packing the rabbits for market a basket or hamper of the ordinary shape and having movable flat slatted trays to enable one to pack the carcasses in separate layers is recommended. Such a hamper permits free circulation of the air not only on the edge but also throughout the package, and the carcasses packed in this way reach their destination in an attractive state, instead of in the messy condition so often seen in the wild rabbits marketed in America.

COOKING AND SERVING.

The cooking of domestic rabbits does not differ greatly from that required for domestic fowls, and an experienced housewife can prepare them in a variety of savory ways. As the meat is naturally somewhat dry, as much as possible of the juices should be retained in cooking it. The following standard recipes for preparing rabbits apply to mature animals of wild and domestic kinds. For young Belgian hares weighing 5 pounds or less and young wild rabbits the time of cooking may be somewhat reduced.

Baked rabbit en casserole.—Lay alternate layers of rabbit and thin slices of bacon, season with thyme, sage, thinly sliced onions, and salt to taste. Fill the dish with water, bake in a slow oven for one and a half hours. A covered baking dish or pan may be used instead of a casserole, and the meat may be boned or not as desired.

Rabbit fricassee.—Brown some butter in a hot iron skillet. Then fry the hare, previously cut up, brown on both sides. Next cover the meat with hot water and stew until it is thoroughly tender, seasoning it to taste. At the end of the stewing, let the meat again fry brown.

Rabbit pot pie.—Cut a dressed rabbit into small pieces; salt and let stand over night. Place the cut pieces in a pot previously filled with warm water enough to cover the meat. Put in a medium-sized onion, sliced, and stew over a medium fire until the meat is tender. Prepare a rich pie-crust dough in the proportions of 1 quart of flour, half a teaspoonful of salt, and a tablespoonful of baking powder, with enough water to give it proper consistency. Roll out flat as for pie crust, spread lard over the surface; fold and reroll twice, spreading lard each time. Line the pan bottom and sides with dough and fill with meat and alternate layers of potato in small pieces and a few small onions. Use the thickened broth from the stew pot as a gravy, pouring it into the pan over the contents. Cover with dough, place in an oven, and bake for an hour, or until the whole upper crust is a light golden brown; serve hot.

The above recipes are offered merely as suggestions. The hind legs and saddles of the rabbit contain much meat and may be cooked in many different ways; boned they make delicious croquettes. The front quarters and head may be used as soup stock; the broth may be seasoned to taste and served with vegetables, barley, or rice.

RABBIT SKINS.

Before the present war an enormous trade in rabbit skins was carried on abroad. Throughout Europe practically all the skins of marketed rabbits were saved. The number produced in Great Britain and Ireland was estimated at about 30 million annually. According to the British trade returns for 1910, there were imported during that year undressed rabbit skins to the number of more than 82 million. Of these over 11 million came from Belguim, nearly 4 million from France, upward of 43 million from Australia, and more than 7 million from New Zealand.

Most rabbit skins are sold in bales by weight, the fur from them being used for felting purposes and the skins utilized for making glue. The better skins are sold by the dozen and when dressed become the "cony" of the fur trade, often sold under fanciful names. White pelts are made up in imitation of arctic fox, or sheared in imitation of ermine.

Gray rabbits are dyed brown or black and become "Baltic black fox" or "Baltic brown fox"; seal-dyed, they became "inland seal," "electric seal," "coast seal," or "near seal." Reputable furriers avoid such names, or, if they use them, frankly explain that the goods are cony or rabbit. Garments made of these furs, though handsome and comfortable, have little durability and are therefore cheap. The pelts, unlike those of American wild rabbits and the hares of the Old World, are strong and durable, but the fur wears off easily.

The war has interfered with importations of rabbit fur from Europe and Australia to such an extent that both hatters' fur and cony have increased greatly in price. Furriers, however, seem to have made little attempt to find or utilize a home supply. American rabbit breeders are raising all the kinds of rabbits that produce the best cony of the fur shops. The climate here is as favorable for fur production as that of central Europe, and there is no reason why the sale of pelts of domestic rabbits from all parts of America should not help materially to increase the breeders' profits.

The fur from rabbits of uniform solid colors is more valuable than that from spotted or piebald varieties. Solid black, white, steel gray, and similar kinds are most in demand, but the fur of the Belgian hare is also desirable. Size and age of the animal are factors in determining the fur value, and winter skins from rabbits kept out of doors are of course superior to those of animals kept in warm quarters or killed when the fur is shedding. Skins of immature rabbits slaughtered for food are less valuable than those of mature animals, but should sell for prices that would repay well the work of skinning and curing them. Rabbit skins intended for manufacture into garments should be taken off "cased," like skins of muskrats or minks. For hatters' fur they are taken off "flat" or "open."

AILMENTS OF RABBITS.

If properly cared for, rabbits are remarkably free from diseases. The more common ailments result from insanitary surroundings, lack of care in feeding, and improper ventilation. The hutches should be cleaned frequently and fresh sawdust or other fine litter used to take up liquids, so that the hutches do not become foul. Such ailments as mange, scurf, surfeit, and the disease of the eyes known as ophthalmia are due usually to foul hutches. Cold snuffles and the like result from improper ventilation, sudden drafts of cold air in overheated buildings, and similar causes. The disorders of the digestive organs come from feeding young rabbits too freely of wet and juicy green foods or from too radically changing their diet. Most diseases are preventable, and if the cause is understood remedies will suggest themselves. For pot-belly, constipation, and like ailments, exercise is the best remedy. If constipation continues, a diet of soft foods or a little castor oil usually gives relief. For diarrhea a little dry barley meal is good, and sometimes powdered acorns in skim milk are an effective remedy.

Incrustations known as ear canker and accumulations of ear wax may be cured by mechanically removing the incrustations with the aid of lukewarm water and then washing with a soft sponge and applying powdered boracic acid. The animal should be held by an assistant. The treatment must often be repeated daily.

The most serious disease known among hutch rabbits in America is coccidiosis. It is caused by internal parasites, and when present in the rabbitry kills many young rabbits. Extreme caution is needed to prevent its introduction, and new stock obtained should for a time be kept isolated from the regular hutches. Keeping the hutches in stacks aids in spreading the infection. Absolute cleanliness may do much to prevent the disease. Whenever a number of the young rabbits under good care develop a pot-bellied appearance, particularly where it is accompanied by symptoms of cold and snuffles, there is reason to suspect that old and apparently healthy animals may be afflicted with chronic coccidiosis and are expelling coccidia from their bodies. Isolation of the affected hutch and its occupants, together with disinfection, is the first step to be taken while the exact nature of the trouble is being determined.

LITERATURE ABOUT RABBITS.

If serious diseases affect his stock, the amateur will find it advantageous to obtain a standard treatise on the management of rabbits. This will contain detailed instruction for the treatment of the more common ailments. As the business of rearing rabbits is carried on much more extensively in England than in America, the best handbooks are published abroad. They may be obtained through any bookseller.

○

Issued May 7, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

SUPERSEDED BY 1090

FARMERS' BULLETIN 496.

RAISING BELGIAN HARES AND OTHER RABBITS.

BY

DAVID E. LANTZ,
Assistant, Bureau of Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

May 18. 1912

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., March 9, 1912.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a report on "The Raising of Belgian Hares and Other Rabbits," by David E. Lantz, assistant in the Biological Survey. The chief purpose of the bulletin is to answer the many letters of inquiry received by the department in regard to the breeding and care of rabbits, which are highly esteemed for food. In it are given brief, practical directions which it is believed will suffice both for those who wish to raise the animals chiefly for home consumption and for others who desire to conduct the business on a larger scale and to raise them for market.

Respectfully,

Henry W. Henshaw,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	3
History and characteristics of the Belgian hare	4
Selection of stock	6
Hutches and pens	7
Food and feeding	9
Breeding	11
Marketing	13
Ailments of rabbits	15
Conclusion	16

ILLUSTRATIONS.

	Page.
Fig. 1. Belgian hare	4
2. A convenient rabbit hutch	8
3. Movable outdoor hutch	8
4. A simple movable outdoor hutch	8
5. A simple outdoor hutch	9

RAISING BELGIAN HARES AND OTHER RABBITS.

INTRODUCTION.

The present bulletin is designed to answer briefly the many letters of inquiry received by the Department of Agriculture, particularly by the Bureau of Biological Survey, relative to the breeding and management of Belgian hares and other domesticated rabbits. No originality is claimed for the subject matter. The principal facts in regard to the raising of rabbits are as well established as those relating to rearing the more important domestic animals, and the volume of directions needed is small. Once launched as a breeder, the amateur will accumulate experience day by day which will soon enable him to avoid gross mistakes in rabbit management.

RABBITS AS FOOD.

In the United States wild rabbits have always been an important source of food, especially during the cold part of the year, and hence less attention has been paid to the breeding of rabbits than in most foreign countries. It would be impossible to estimate correctly the number of rabbits marketed and eaten in Great Britain. Not only are the home warrens and farms drawn upon for a supply, but from 10,000 to 12,000 tons are imported annually, coming partly from the Continent, but in greatest numbers from Australia and New Zealand.

In France, Holland, and Belgium rabbits are a common article of diet and rabbit breeding is general on farms, especially where the land holdings are small. Spain produces many domestic rabbits and is sometimes regarded as the original home of the common European rabbit (*Lepus cuniculus*), since Strabo, writing about the beginning of the Christian Era, stated that ship cargoes of rabbits were brought to the Roman markets from that country. Whether or not the European rabbit is superior as food to the wild cottontail rabbit of our forests and fields is a matter of individual taste. The so-called Belgian hare is merely a domesticated form of the wild rabbit of Europe, long bred with special reference to the development of a superior food animal. Its flesh is generally considered better than that of the ordinary hutch rabbit.

HISTORY AND CHARACTERISTICS OF THE BELGIAN HARE.

ORIGIN.

The Belgian hare probably originated in Belgium or northern France. It was quite generally known in the northern part of Continental Europe before the attention of English fanciers was directed to it. As their first stock came from Belgium, that country was credited with having originated the breed, which was exploited in England and elsewhere as being a cross between the rabbit and the wild hare (*Lepus timidus*).[1] This claim seems to have been fully disproved by many unsuccessful efforts to produce the same cross. The chief known reason for calling the animal a hare lies in its color resemblance to the wild hare. (Fig. 1.)

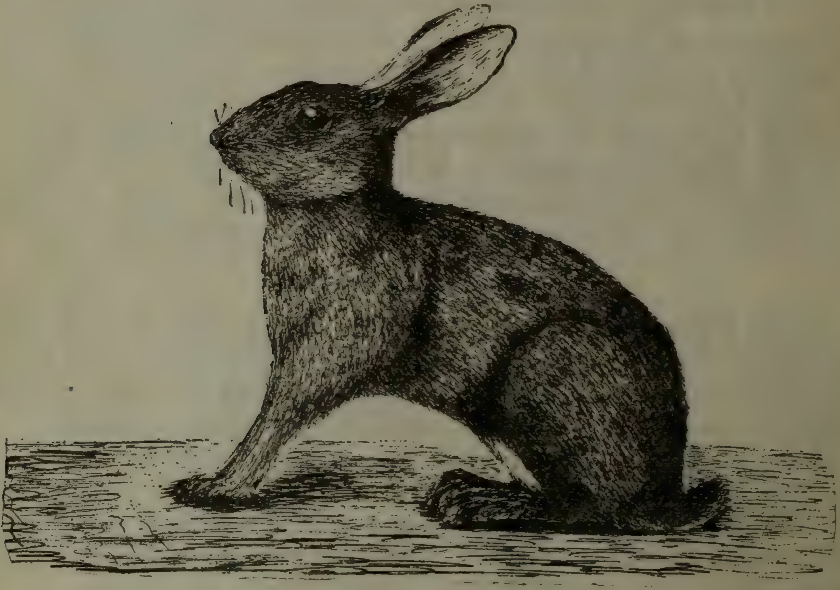


FIG. 1.—Belgian hare.

THE BELGIAN HARE IN AMERICA.

In the hands of English fanciers, the Belgian hare was greatly improved, and it is still a popular breed with them, although the fad for it never reached the acute stage shown later among American breeders. The animal was introduced into this country over 20 years ago, and within a few years its popularity became astounding. The finest show animals commanded enormous prices and extraordinary claims were made as to the excellence of the breed for the table. As was natural, when the reaction came and the public found out that the Belgian hare is a rabbit not much superior to other kinds, the animal was unjustly condemned and execrated. As a consequence, the whole business of breeding domestic rabbits in the United States has for the past few years been much neglected.

---

[1] J. Simpson, in The Wild Rabbit (London, 1895), states that the Belgian hare is such a hybrid, and that it was originated by a M. Roux, of Angoulême, France.

In spite of the setback caused by the collapse of the Belgian-hare bubble, this breed has maintained a greater popularity than any other, and many breeders are still raising it. The Flemish giant, owing to its greater size, is preferred by some. The fact that rabbits are easily grown and are a cheap and excellent substitute for the ordinary meats is likely to turn the attention of many more persons to rearing the animals. That they can be propagated without costly investment in land and buildings is a peculiar advantage. Further, the presence on the farm of another animal which, like poultry, may be killed and prepared for the table entire and at short notice, is exceedingly desirable. All these circumstances make it extremely probable that the business of rearing rabbits will grow in importance. The tendency in this direction is evidenced by the increasing number of inquiries about the management of the animals received by the Department of Agriculture. The greater number of these relate to the Belgian hare.

THE BELGIAN HARE AS FOOD.

The Belgian hare is one of the best rabbits for table use. It weighs more than most breeds, develops very rapidly, and the quality of the meat is superior to all the others. The Flemish giant is a Belgian hare bred exclusively for large size, but with the result that the meat is coarser and less delicate in flavor. These characteristics are regarded by some persons as desirable, but this is largely a matter of individual taste. Most people would prefer the white, finer-grained flesh of the original Belgian hare. It should be remarked, however, that much of the excellence of the rabbit as food depends upon its cooking. As often prepared, it is dry and insipid; while in the hands of an experienced cook it becomes all that the most fastidious taste can wish. An especial requirement in cooking the Belgian hare is that none of the natural juices of the meat be lost in the process.

CARE OF OTHER BREEDS OF RABBITS.

The directions herein given for the care of Belgian rabbits are applicable to the management of most other breeds. The ordinary English rabbit, regarded as of less value as a food animal, is even more hardy and therefore needs less care. The lop-eared rabbits and possibly a few other breeds require artificially heated quarters in winter, but in other respects their management is the same as for the Belgians.

SELECTION OF STOCK.

If one breeds rabbits for food only and not for show purposes, the selection of stock is of less importance. All that is required is a sizable animal of good, hardy stock. However, the points for which the fancier breeds the Belgian hare include also those most desirable in a food animal, so that if one can find stock with these characters well marked, and at the same time constitutionally sound, he should by all means obtain it. Purebred stock is more profitable, too, because it may be sold for breeding purposes as well as for the table.

Color.—Belgian hare fanciers of a few years ago differed somewhat in opinion as to the proper standard color for this animal. Some aimed at the color of the wild English hare—a sandy light brown. Most American breeders seem to have preferred a deeper reddish brown. In all other respects the standards were the same. The chief requisite concerning color is that it shall be as nearly uniform as possible throughout the upper surface of the animal and that the fur shall have a rich luster. The "ticking," or shading, should be wavy rather than dotted. The belly and lower surface of tail and hind feet should be whitish, but not pure white. The neck and breast are somewhat lighter in shade than the back, but not in marked contrast with it, nor should the change in shade be abrupt.

Ears.—The ears of the mature Belgian should be about 5 to 5½ inches in length, varying with the size of the specimen. They should be well shaped, strong at the base, and almost transparent at the middle. They must not be pendulous, but should, when the animal is quiet, be inclined backward, resting straight over the shoulders. A narrow black edging at the tip and as far down the front and back as possible marks the best specimens.

Body.—The body of the Belgian is longer in proportion to the whole bulk than that of any other breed of the same size. Bucks and the younger females should never have the appendage known as "dewlap." This sometimes develops in the older does, but is regarded as a blemish in animals intended for show purposes. The back should be only slightly arched and the forelegs and feet should be perfectly straight and free from white.

Age of breeding stock.—The beginner should always select mature animals about a year old for breeding stock. These may be known by the brisk, alert look, the small white teeth, and the small claws, almost hidden in the fur. Coarse, long claws are a sure indication of age. He should avoid listless-looking, rough-coated, or pot-bellied animals (except pregnant does), and especially those having the whites of the eyes stained with yellow. A hutch rabbit in good health is gentle, neither savage nor overtimid, and does not scream when lifted by the ears.

The sexes.—The does selected for breeding may be of the same strain and even of the same litter, but the buck should be of different stock, and when possible obtained from another breeder. Hardy animals with the best characteristics of the breed may be bought at from $1 to $2 each. They may often be had of near-by breeders, and thus save the expense of carriage on long journeys by express.

HUTCHES AND PENS.

The Belgian hare does not do well when kept wild in open warrens. The common English rabbit is better for this purpose. A good many Belgians have been turned out in various parts of the United States, and in the vicinity of the city of New York and on the western coast there have been some complaints of damage to crops by wild Belgian hares. As a rule, however, and fortunately for the farmer, these animals, when obliged to shift for themselves, fall an easy prey to their enemies and disappear within a few months.

Belgian hares may be successfully managed in two ways: (1) Entirely in hutches, or (2) in outdoor fenced runs, or courts, with hutches for does when having young, and sleeping hutches for other stock. The hutch system with various modifications is the more common, and is the only method adopted by rabbit fanciers who raise for show. The use of small runs or rabbit courts to give the animals healthful exercise in fine weather is of advantage.

THE RABBITRY.

The rabbitry may occupy part or all of a barn or shed, or be built in a sheltered space in the angle between buildings or walls. The indoor rabbitry has decided advantages. The place should be well ventilated, but not subject to draughts of cold or damp air. These may be prevented by ventilators in the roof, or by a system of elbowed pipes passing through the sides of the building and reaching a height of 2 or 3 feet above the openings.

HUTCHES.

Hutches for the Belgian hare should be somewhat larger than those intended for smaller breeds. They should be built of good lumber, should have tight floors, and should have at least 12 square feet of floor space and a height of 2 feet. If there is plenty of room in the rabbitry it is best to have the hutches separate; but they are usually set in tiers or stacks, two or three in height. Each hutch in the rank is complete in itself, so that its position may be shifted at any time.

A convenient indoor hutch (fig. 2) is one 6 by 2 by 2 feet, with a movable partition dividing off a third of the space at one end for a nest and sleeping chamber. The partition has a smooth hole to permit passage of the animals from one part to the other. The front of the hutch has two doors, one of wire netting, the other of wood. The wooden door leads to the sleeping chamber and should close tightly. It is best to use metal hinges for the doors. The partition may slide in a groove between the doors or may be put in and taken out through one of the door openings.

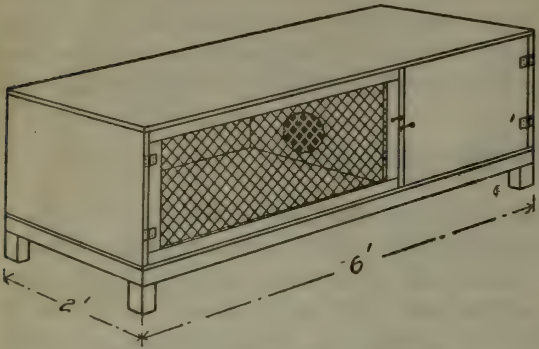


FIG. 2.—A convenient rabbit hutch.

Outdoor hutches should have sloping roofs and overhanging eaves to protect them from rain. The screened door should have a sliding cover of wood or be fitted with a removable cloth cover. Small holes bored near the top of the hutch will afford all necessary ventilation.

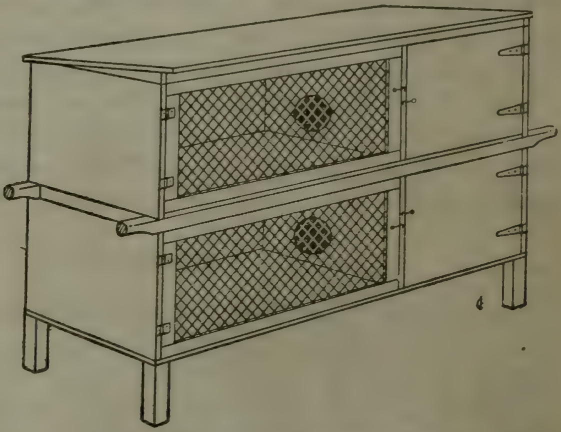


FIG. 3.—Movable outdoor hutch.

Movable hutches (fig. 3) have some advantages. They may be carried outdoors in fine weather and taken back under shelter at night or during storms. Long, narrow cleats projecting at both ends of the hutch are all that are needed to convert the ordinary hutch into a movable one. Two forms of outdoor hutch sometimes used are shown in figures 4 and 5. That in figure 4 has no floor except a wire screen, permitting the rabbits to eat grass or other herbage that projects through the netting.

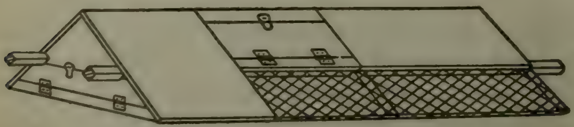


FIG. 4.—A simple movable outdoor hutch.

COURTS.

A rabbit court may be paved or floored, or it may be a grass court surrounded by a rabbit-proof fence. Sleeping hutches inside the court may be small boxes of any sort if they are stout and waterproof. They should have sliding doors to confine the rabbits if desired, and should also have small holes near the top for ventilation. If a court is used, hutches will still be needed for the breeding does.

A rabbit-proof fence to inclose a grass court should be made of heavy poultry netting 5 or 6 feet wide and of 1½-inch mesh. The posts, projecting 3 or 4 feet above the ground, should be well set outside the edge of the court. The netting is stapled to the posts, leaving a projection of 6 inches or more at the top and about 18 inches at the ground, to be turned into the court. The lower edge should be covered with 10 or 12 inches of soil to prevent the animals from digging out. The upper edge is also turned inward to keep them from climbing over. Brackets at the tops of the posts make the best support for the overhanging netting, although horizontal pieces of wood nailed to the posts will answer.

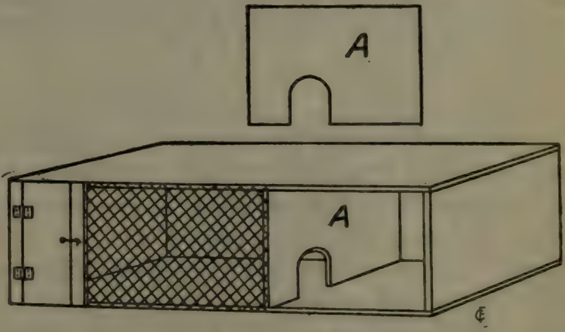


FIG. 5.—A simple outdoor hutch.

FOOD AND FEEDING.

The rabbit thrives well on a diversity of vegetable foods. Many writers on the care of this animal prescribe elaborate lists of foods to be followed week in and out. The fact is that a few staple foods are sufficient, but no animal is more adaptable to sudden changes of diet; so that one can feed what is available or cheap, the idea being to produce weight with the least possible outlay of money.

GRAIN AND HAY.

The best grain for rabbits is oats, either whole or crushed, though corn meal, barley, or other grain may often be fed by way of change. The crushed oats are best when freshly broken, and a hand mill for preparing them is a valuable adjunct to a rabbitry.

Hay is a necessary part of the rabbit's diet and if possible that of the very best quality should be used. It should be entirely free from moldiness, and the unsweated is always preferable. If one has small grounds where suitable grass grows, the mowing may be done at short intervals and the hay thoroughly cured in such small quantities that no sweating takes place. However, if sweet hay is not available the sweated may be fed to the rabbits without injury, unless it be moldy.

GREEN FOODS.

Rabbits require some green foods for winter. Cabbages, kale, spinach, and rape leaves are recommended. Turnips, beets, and mangels are often fed, and have been recommended by many rabbit breeders, but they do not keep so well as the foods just named. Turnips, unless kept in the ground, wilt by midwinter and are then of little use. Beets and mangels keep better, and the latter are the main dependence of some English rabbitries; but, on the whole, cabbages are more economical, as well as more satisfactory in every way. They are usually available until green stuff grows in the spring. Whatever green food is put away for winter use must be stored where frost can not touch it, as freezing unfits it for rabbit food. Parsnips left in the ground all winter make an excellent early spring rabbit food after the frost leaves the ground in which they grow.

FEEDING.

Rabbits should be fed twice daily. Ordinary stock is fed morning and evening, but suckling does should have also a noon meal or be given more than they will eat at the other meals. The general rule is to feed only as much grain or green stuff as the animals will consume. Hay is put into the hutch to be available at any time, a part of it being left as litter. The exact amount of grain or green stuff for each rabbit at a meal can not be stated, as the appetite varies greatly at different times. Observations of the quantity left over when the animals quit feeding will soon enable the feeder to adjust the meals to the needs of the rabbits. Overfeeding is a much more common mistake than underfeeding.

Winter feeding.—In winter, one of the meals each day should be chiefly of green food (as roots or cabbage), and the other mainly of grain. Roots, cabbage, celery, and the like should be previously washed clean of soil, but should not be wet when given to the rabbits. If green food is given in the morning, the evening meal should be whole oats or other grain for mature animals. Those under 3 months of age should be given crushed oats with a little bran, as they can not so well masticate whole grain. A little hay should be given with each meal.

Summer feeding.—In summer, green food should be the chief reliance, and only a small quantity of hay or grain is needed. Rabbits are fond of all kinds of garden vegetables, besides wild parsley, dandelion, plantain, dock, and other weeds, as well as grasses. Agreeable changes in diet are always possible in summer, but overfeeding should be avoided and also the feeding of stuff that is wet with dew or rain. It is best to cut clover or other green food in the afternoon before the dew falls and to spread it under shelter so that it will not heat, but be still fresh at feeding time.

Corrective feeding.—Occasionally a warm mash of cooked potatoes or of the leaves of clover hay mixed with "chops" or a little bran is desirable. Sometimes a little sulphur may be sprinkled with the mash, although a little flour mixed with the ordinary grain has about as good an effect in correcting looseness of the bowels. In cold weather some breeders feed a warm mash each evening.

Unless green food is abundant rabbits should be given water daily. In warm weather the water pans should be filled with fresh water twice each day. The does suckling young or soon to have young should be given milk diluted with one-third warm water.

A piece of rock salt kept in each hutch affords a steady supply as needed and makes it unnecessary to supply salt in the food.

Rabbits under 3 or 4 months old should be limited in the amount of green food. If allowed too much they are apt to become "pot-bellied." When a young rabbit is seen to grow big about its belly, the use of green food should be discontinued and the animal given plenty of exercise. Under such treatment it will soon recover, but if the green food is continued the disease usually terminates in convulsions and death. Old rabbits are not subject to this trouble.

BREEDING.

AGE FOR MATING.

It is not desirable to pair rabbits until they are at least 6 months old, although they may be bred earlier. Some breeders do not mate animals under 10 months of age. Healthy mature rabbits produce larger and stronger litters than younger stock do.

METHODS OF MATING.

Different breeders adopt different methods of mating. Some leave the buck in the hutch of the doe for but a few minutes, while others leave him over night. The older does should be mated in February, but it is well to defer mating a young doe until March. She then has young in April, when there is abundant green food to induce a good flow of milk. This lacteal development once well established, she is likely always to give abundance of milk for her young. If one begins to pair in February he should expect to have each doe produce four litters a year, the young coming at intervals of about 12 weeks, with a longer rest in midwinter.

PREPARING FOR THE YOUNG.

The gestation period of the rabbit is about 30 days. When the doe is nearly ready to bear young, her hutch should be thoroughly cleaned and disinfected, after which a good supply of soft hay or straw (oat straw is best) should be placed in the body of the hutch to enable the doe to arrange her nest. If the hutch is without a nesting compartment, a box should be placed in a corner. It should be 18 to 20 inches long, about a foot deep, 8 or 10 inches wide, and without a lid. Make a hole in one end large enough for the doe to pass through easily, and turn the box upside down. The doe will arrange her nest a day or two before the young are born. At this time extra attention should be given to her food. She should have milk and warm water regularly, and a pan of clean water should be kept constantly in the hutch. While a doe is heavy with young and for a few days after their birth, extreme care should be taken to see that she is not frightened by cats or dogs or even by strange visitors in the rabbitry. Avoid touching the nest or handling the young, unless it is absolutely necessary.

DIET WHILE NURSING.

During the first week or two after having young the doe may be fed almost entirely on warm milk and bread. This is recommended for the bulk of the morning and evening meals, with a small supply of green food. Green food may be given also in the middle of the day, and the daily proportion gradually increased. Boiled mush made of corn meal is also an excellent food for suckling does, but most other pasty or watery foods should be avoided as likely to derange the bowels. Milk, and indeed any soft food, should be fed in a separate earthenware dish, especially in warm weather, when it sours quickly. The dish should be often washed and scalded.

NUMBER OF YOUNG.

The number of young produced by the Belgian hare varies greatly. Litters of 10 or 12 occur, but these are too large for a doe to raise. An average of 6 or 7 is all that should be saved. It is of advantage to have several does breed at about the same time, for the number of young may then be adjusted by transferring from those that have too many to those having few. The young begin to leave the nest when about 3 weeks old. At this time the nesting box or compartment should be thoroughly cleaned and disinfected and then furnished with fresh straw or hay.

WEANING.

The young may be weaned when a month old, but it is better to leave them with the doe two or three weeks longer. Remove two each day until all are transferred to another hutch, which may be large enough to accommodate any number. They do well together until they are 3 or 4 months old, when their development will compel separation of the sexes. After this any number of does may occupy the same hutch, but bucks, unless thoroughly accustomed to each other, will fight.

MARKETING.

At 4 months the young Belgian hare should be ready for market, and if it has been properly fed should weigh about 6 pounds or even more. This weight is about the best for market rabbits, and immediate sale is more profitable than keeping to maturity. Some breeders sell at 10 to 12 weeks and aim to have their stock weigh about 5½ pounds at that age. To do this requires that the animals be kept in small hutches where they can have but little exercise and that they be fed heavily from the time they are weaned. Under this treatment they grow very rapidly and are really superior for the table.

MARKET RETURNS.

It is not easy to state what a breeder should realize for market rabbits. Much depends on local conditions and especially upon the familiarity of the public with the excellence of hutch rabbits for the table. If the animals are new to a market, a demand for them will have to be built up, but as a rule they will soon become popular. Better prices can usually be had by selling directly to the consumer, thus saving the middlemen's profit. One may make arrangements to deliver regularly or periodically to hotels and restaurants, but often a poultry dealer will agree to take a certain quantity at regular intervals. A breeder of Belgian hares near a military post in Virginia informs the writer that he finds ready sale for all he can spare at 20 cents a pound, dressed. In England, where rabbits are almost as common in the markets as fowls, the prices paid by poulterers for the carcasses average 5d. to 6d. (10 to 12 cents) per pound. If as much can be had for them here the rearing of rabbits should be about as profitable as growing poultry for the table. If members of the family look after the rabbits, so that there is no outlay for labor, and if the hutches are built at home, the cost of rearing may be greatly reduced and much of the income will be net gain. While it must be admitted that rabbits require more care than is usually given to poultry on our farms, their management has the advantage that it is more interesting, especially to the younger members of the family.

DISPOSING OF SURPLUS.

After selecting the best stock for breeding purposes it is well to dispose of the remainder as rapidly as conditions warrant. If those to be sold are to be marketed alive all that is needed is to crate them properly and forward them to their destination. This is the better plan in hot weather, as the carcasses do not keep well. If carcasses are to be delivered the methods of killing and packing are important considerations.

KILLING.

There are two excellent ways of killing the animals. The easier and probably the more humane is to dislocate the neck. Almost all gamekeepers know this method and can quickly show the novice how it is done, but probably a description will be understood. Take the two hind legs of the rabbit firmly in the left hand, place the thumb of the right hand just behind the ears where the neck joins the skull, the palm resting on the left side of the face and the fingers holding firmly under the jaws. Then stretch out the animal quickly and with force, pressing in the right thumb and bending the head backward. The dislocation will be distinctly felt. While this method requires considerable strength, when the knack of it is learned it entails less suffering than any other. Another excellent way of killing is to hold the rabbit up in the left hand, as in the first method, and then to strike a sharp blow on the back of the head with a round stick, stunning the animal. As soon as the neck is dislocated or the rabbit stunned the jugular vein should be cut with a sharp knife and the animal hung head downward to bleed.

DRESSING.

The next step in preparing a carcass for market is to remove the paunch and entrails, as their presence would soon taint the meat. With a sharp-pointed knife make a longitudinal cut down the middle of the belly, dividing the skin and the thin abdomen walls, but being careful not to cut the intestines. Turn out the paunch and the intestines, but leave the lungs, liver, heart, and kidneys in place. Next make a slit between the large tendon and the bone of one hind leg and slip the other leg through the cut, so that the carcass may be readily hung up. It should hang long enough to stiffen before being packed.

PACKING.

For packing the rabbits for market a basket or hamper of the ordinary shape and having movable flat slatted trays to enable one to pack the carcasses in separate layers is recommended. Such a hamper permits free circulation of the air not only on the edge but also throughout the package, and the carcasses packed in this way reach their destination in an attractive state instead of the messy condition so ofter seen in the wild rabbits marketed in America.

RABBIT SKINS.

An enormous trade in rabbit skins is carried on abroad. Throughout Europe practically all the skins of marketed rabbits are saved. The number produced in Great Britain and Ireland is estimated at about 30,000,000 annually; while, according to the English trade returns for 1910, there were imported during that year undressed rabbit skins to the number of 82,327,101. Of these over 11 millions came from Belgium, nearly 4 millions from France, upward of 43 millions from Australia, and 7,379,960 from New Zealand. Most of the skins are sold in bales by weight and only the fur from them is utilized in making felts and other cloths. The better skins, however, command good prices and are made up into garments in imitation of more costly furs. Skins of arctic hares and white rabbits are used to imitate ermine and arctic fox. Skins of Angora and silver gray rabbits sometimes sell for a shilling or more each. Belgian hare skins are usually dyed to imitate black fox or the so-called "black lynx." They are worth several cents each when untorn.

AILMENTS OF RABBITS.

If properly cared for, rabbits are remarkably free from diseases. The more common ailments result from insanitary surroundings, lack of care in feeding, and improper ventilation. The hutches should be frequently cleaned and fresh sawdust or other fine litter used to take up liquids, so that the hutches do not become foul. Such ailments as mange, scurf, surfeit, and the disease of the eyes known as ophthalmia are due usually to foul hutches. Cold snuffles and the like result from improper ventilation, sudden drafts of cold air in overheated buildings, and similar causes. The disorders of the digestive organs come from feeding young rabbits too freely of wet and juicy green foods or from too radically changing their diet. Most diseases are preventable, and if the cause is understood, remedies will suggest themselves. For pot belly, constipation, and like ailments, exercise is the best remedy. If constipation continues, a diet of soft foods or a little castor oil usually gives relief. For diarrhea a little dry barley meal is good, and sometimes powdered acorns in skim milk are an effective remedy.

Incrustations known as ear canker, and accumulations of ear wax may be cured by mechanically removing the incrustations with the aid of lukewarm water, and then washing with a soft sponge and applying powdered boracic acid. The animal should be held by an assistant. The treatment often requires repeated daily application.

The most serious disease known among hutch rabbits in America is coccidiosis. It is caused by internal parasites and when present in the rabbitry kills many young rabbits. Extreme caution is needed to prevent its introduction, and new stock obtained should for a time be kept isolated from the regular hutches. Keeping the hutches in stacks helps to spread the infection. Absolute cleanliness may do much to prevent the disease. Whenever a number of the young rabbits under good care assume a pot-bellied appearance, particularly where it is accompanied by symptoms of cold and snuffles, there is reason to suspect that old and apparently healthly animals may be afflicted with chronic coccidiosis and are expelling coccidia from their bodies. Isolation of the affected hutch and its occupants, together with disinfection, are the first steps to be taken while the exact nature of the trouble is being determined.

If serious diseases affect his stock, the amateur will find it advantageous to obtain a standard treatise on the management of rabbits. This will contain detailed instruction for the treatment of the more common ailments. As the business of rearing rabbits is carried on much more extensively in England than in America, the best handbooks are published abroad. They may be obtained through any bookseller.

CONCLUSION.

While not affording large profits, the business of raising rabbits in a small way may be made an interesting as well as a reasonably remunerative adjunct to other pursuits. It is adapted to small village places, as well as to farms, and under careful management the returns from it are likely to increase as one gains experience. Under favorable circumstances it is capable of expansion into a serious vocation. The presence of rabbits in inclosures on the farm or on village premises furnishes opportunity for an agreeable change in the family diet, a fact that is of considerable importance when ordinary meats are high priced, or in regions where they are difficult to obtain.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

○

My.5.40

SOME COMMON GAME, AQUATIC, AND RAPACIOUS BIRDS IN RELATION TO MAN

W. L. McATEE and F. E. L. BEAL
Assistant Biologists

Red-Tailed Hawk

FARMERS' BULLETIN 497

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Biological Survey
E. W. NELSON, Chief

Washington, D. C. Issued May 6, 1912; reprint, December, 1917

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

[illegible]

FROM a purely practical point of view the most important of the relations of native birds to man are the economic. The esthetic value of birds is great, greater indeed than that of any other group of animals; and that this is a real and especially a treasured value is not to be denied.

In their relation to insect and other enemies of crops birds are most directly associated with the welfare of mankind, and their value in this particular should be made as widely known as possible. This bulletin is one of a series designed to assist in doing this.

Not all birds are beneficial, but all facts tending to show in which class each species belongs being set forth, the useful kinds will be found to far outnumber the injurious, and so great is their value as insect destroyers in the United States that to them may be given the credit of being one of the greatest controlling factors in limiting the development of insect pests and in preventing many disastrous outbreaks.

In the following pages are discussed the food habits and relation to man of 19 species of game, aquatic, and rapacious birds, including 5 species of hawks and owls.

SOME COMMON GAME, AQUATIC, AND RAPACIOUS BIRDS IN RELATION TO MAN.

CONTENTS.

	Page.		Page.
Prairie chicken	3	Franklin's gull	17
California quail	5	Terns	20
Ruffed grouse	10	Cooper's hawk	24
Introduced pheasants	11	Rough-legged hawk	25
Upland plover	12	Sparrow hawk	26
Killdeer	14	Long-eared owl	27
Horned grebe	16	Screech owl	27

GAME AND AQUATIC BIRDS, as a rule, have less economic interest than the species more closely associated with man. Nevertheless nearly all aquatic birds have important relations with the fishing industry. One of the birds, the horned grebe, sometimes accused of living entirely upon fish, is here shown to feed largely on crawfish, other crustaceans, and insects. Terns also have been held responsible for the serious reduction of food fishes in some localities, but a careful study of their food habits demonstrates that only a small proportion of their diet consists of such fishes. Certain aquatic birds approach the land birds in feeding habits; examples are Franklin's gull and the black tern, both of which by their destruction of insects are beneficial to man.

All the shorebirds are strikingly beneficial in their food habits, and the slaughter of these game birds deprives the farmer of valuable allies against some of the worst crop pests. The gallinaceous game birds, as quail, grouse, and pheasants, take far less insect food than the shorebirds, yet all of them do a certain amount of good. Because of their close contact with crops it is important that their economic relations be made widely known. The hawks and owls have a bad name, but for the most part it is undeserved, and indiscriminate persecution of these birds is a serious mistake.

PRAIRIE CHICKEN.

(*Tympanuchus americanus.*)

The prairie chicken (fig. 1), now common only in Kansas, Nebraska, Minnesota, the Dakotas, and Manitoba, is one of the birds which formerly occurred over a much wider range than at present and in far greater abundance. It has been reduced principally by hunters, as have so many of our finest species of birds. Many sportsmen declare allegiance to the highest principles of game preservation yet fail to practice these principles. Our present game laws, even though efficiently administered, will save no species of birds, as the rapid growth of the army of sportsmen and pot hunters more than counterbalances the effect of the shortening of open seasons and reduction of bag limits. Moreover, game laws, as a general rule, are not strictly obeyed. In southern Wisconsin, where there was a closed season on prairie chickens for a term of years, to the writers' knowledge these birds were killed at every opportunity. The customary excuse was: "They are so scarce they won't breed up again anyway." Aside from showing culpable willingness to assist in the birds' extermination, this remark is untrue. Like all birds of its family the prairie chicken is very prolific, and if adequately protected would soon become numerous in its old haunts. The bird is easily domesticated, hence is eminently suited for propagation on preserves As the increase of game in this manner is the only way to preserve it indefinitely and at the same time allow hunting, the plan

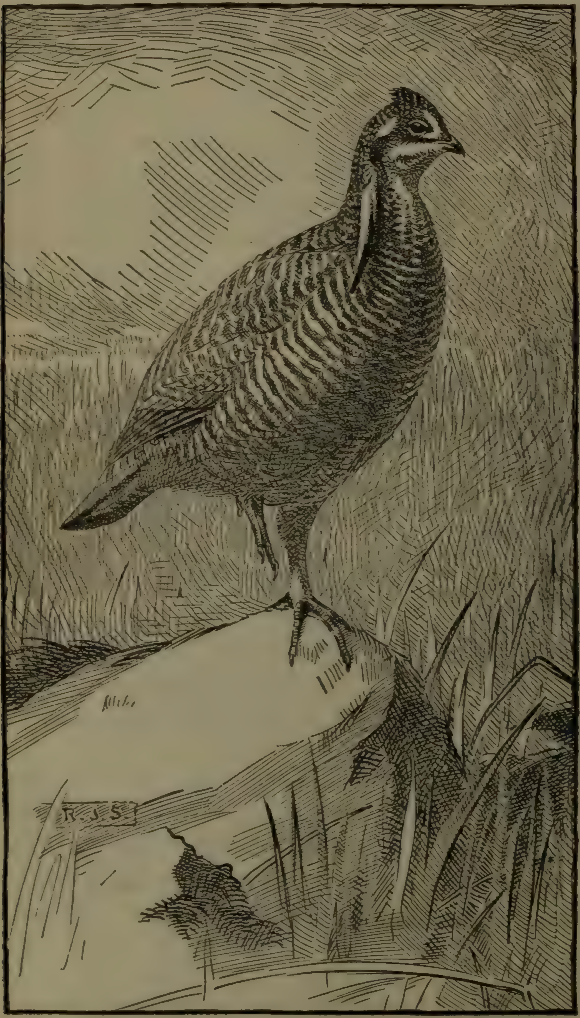


FIG. 1.—Prairie chicken.

should be actively put into operation by those most interested in the preservation of game—the sportsmen.

The prairie chicken is valuable not only as game, but as an efficient destroyer of farm pests, and any farmer would profit by having these birds reared on his place. Almost 15 per cent of the bird's food consists of weed seeds, including those of such pests as foxtail grass, smartweeds, and ragweed. More than 10 per cent of the diet consists of rose hips. A few other fruits are eaten and more than a fourth of the food consists of leaves, flowers, and shoots, collectively known as browse. The prairie chicken eats a great deal of grain, but takes most of it from stubble. The bird is fond of such mast as hazelnuts and acorns.

Nearly 15 per cent of the bird's food consists of insects, the bulk of them being grasshoppers. Almost every kind of grasshopper, locust, or cricket appears to be acceptable, and nearly 20 different kinds were identified from the stomachs. The prairie chicken made itself especially useful during the destructive invasions of the Rocky Mountain locust. Sixteen birds examined at that time were found to have eaten 866 locusts. Among other pests eaten by this species are the Colorado potato beetle, 12-spotted cucumber beetle, sugar-beet leaf-beetle, May beetles, cotton worm, army worm, cutworms, the yellow bear caterpillar, and chinch bug.—W. L. M.

CALIFORNIA QUAIL.

(*Lophortyx californica.*)

The California quail (fig. 2) is common and generally distributed over the States west of the Sierra, except at the higher altitudes, and is especially abundant in the fruit-raising sections. Like the bob-white of the East, this quail never goes far from cover, and it delights to dwell on unimproved land where trees and chaparral alternate with small areas of open ground. In settled regions it is somewhat domestic in habits and soon becomes accustomed to living in orchards, gardens, and cultivated grounds. The writer has seen a female sitting upon her eggs in a garden within 30 feet of a house, between which and the nest carriages and foot passengers passed many times each day. In winter a covey frequently feeds with the farmer's chickens, and if not disturbed will continue to do so until pairing time.

The natural food of the quail consists of the seeds of the vast number of plants known as weeds, with a little foliage of the same, especially in winter, when the leaves are young and tender. Considering how small is the amount of fruit usually found in the stomach of this bird, it is a surprise to learn that it sometimes does serious damage to vineyards. Investigation, however, shows that, as in most other similar cases, the injury results only when too many birds gather in a limited area. Nearly all the complaints against the quail for eating fruit are that it visits vineyards in immense numbers and eats grapes. When thousands visit a vineyard, even if only occasionally, and each bird eats or spoils at least one grape, the result is disastrous.

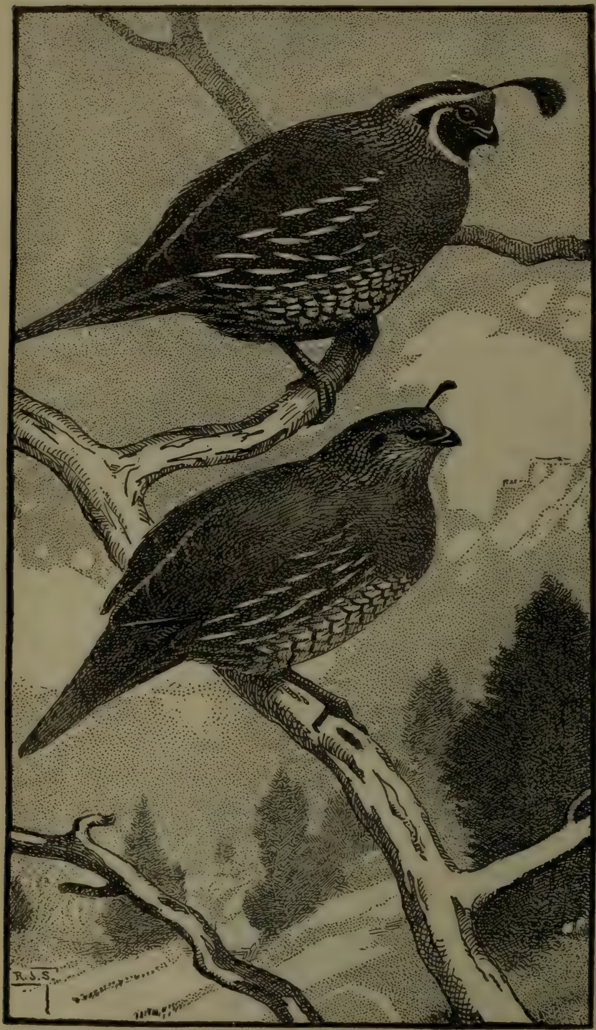


FIG. 2.—California quail.

An observer states that he once saw a flock of about 1,000 quail eating Zinfandel grapes in a vineyard in the central part of the State, and another says that in southern California he has seen as many as 5,000 feeding upon Muscat grapes. In the writer's interviews with California fruit growers, only one mentioned the quail as harmful. His ranch was situated along the hills on the side of a narrow valley, adjacent to wild grazing land with much chaparral and forest, among which the quail lived. In this case the annual loss was estimated at 2 or 3 tons of grapes.

In the laboratory investigation of the food of the California quail 619 stomachs were examined. They were collected in every month except May, but only one was obtained in March. The other months are well represented. Animal food, principally insects, amounts to but 3 per cent, and most of this was found in the stomachs of young birds, mere broodlings. Vegetable food amounts to 97 per cent and consists mainly of seeds of plants most of which are of noxious or troublesome species.

Animal food.—Ants appear to be a favorite food. They were found in 82 stomachs, and were eaten by adults as well as by young. They amount, however, to less than 1 per cent of the whole diet. The rest of the animal food aggregates a little more than 2 per cent and is distributed as follows: Beetles in 30 stomachs, bugs (Hemiptera) in 38, caterpillars in 11, grasshoppers in 7, flies in 2, spiders in 6, millepeds in 1, and snails in 2. The most interesting point in this connection was the stomach of a broodling only 3 or 4 days old. Besides several adult Hemiptera, some ants, caterpillars, and spiders, and a few seeds, it contained 280 minute insects, which constituted 76 per cent of the stomach's contents, and were identified as an immature form of species of scale, *Phenacoccus helianthi.*

In this connection the following extract from a letter dated at Los Angeles, Cal., October 28, 1908, by Dr. W. G. Chambers to the Secretary of Agriculture, is interesting:

> Last May during the hatching season one of my female quail died a week prior to completing the hatch. An incandescent light of 8 candlepower was substituted, the result being 15 baby quail, very wild at first, not understanding human sounds or language, but finally becoming as docile as pet chickens. They were raised in my back yard, running at large after the first week.
>
> A number of Marguerite bushes which grow in profusion in the yard were so infested with black scale that I had decided to uproot them and had postponed doing so as the little quail worked so persistently among the branches; upon investigation I discovered them eating the scale and twittering happily; they would swallow the fully developed scale and thoroughly clean the branches of all those undeveloped.

The young in the first week of life eat animal matter to the extent of from 50 to 75 per cent of the food, but by the time they are 4 weeks old they take little if any more animal food than the adults.

Vegetable food.—The vegetable part of the quail's food may be divided into fruit, grain, seeds, and forage. Fruit appeared in 106 stomachs and aggregates 2.3 per cent of the yearly diet. It was distributed as follows: Grapes in 7 stomachs, prunes in 9, apples in 3, rubus (blackberry or raspberry) in 4, olive in 1, elderberry in 21, snowberry in 8, Manzanita in 2, huckleberry in 11, and rose haws in 3. Pulp and skins, identified as fruit only, were found in 27 stomachs, and unknown seeds, probably those of some small fruit or berry, occurred in 10 stomachs. It is evident that the percentage of any one of the above is insignificant. Stomach examination throws no new light upon the quail's grape-eating habits, except to show that the ravages complained of are exceptional. That fruit does not constitute any important part of the bird's annual food is clearly proved.

Grain was found in 133 stomachs and constitutes 6.4 per cent of the food. It was distributed as follows: Corn in 14 stomachs, wheat in 15, oats in 13, barley in 89, and rye in 2. The principal complaints against the quail on the score of grain eating are that flocks sometimes visit newly sown fields and eat large quantities of the seed. Walter E. Bryant says on this point:

> Two males which I shot one evening as they were going to roost for the night after having been feeding on a newly sown field contained the following, mainly in the crop: (*a*) Two hundred and ten whole grains of barley, 6 pieces of broken barley, 3 grains of "cheat," and 1 of wheat, besides a few barley hulls, some clover leaves, and alfilaria; (*b*) 185 whole grains of barley, 5 broken pieces, 4 grains of "cheat," and 2 of wheat; also barley hulls, clover, and alfilaria. The flock numbered nearly or quite 20 birds.[1]

Only one report accuses the bird of eating grain from the harvest field. Mr. W. T. Craig, of San Francisco, writing to the United States Department of Agriculture, says:

> I have observed the quail enter a field of wheat to the number of thousands, and had they not been driven away they would have destroyed the whole crop.

Stomach examination does not indicate any month in which grain is eaten in excess of other food. January shows the highest percentage, 12.4, but November is nearly as high, while December, although between the two, shows less than 3 per cent. A little more than 3 per cent was eaten in February, and none at all in March and April, though the newly sown grain would be accessible in one at least of these months. June and July, the harvest months, show, respectively, 4.1 per cent and 10.7 per cent. In fact the stomach record plainly indicates that the quail does not make special search for grain, but being naturally a seed eater takes grain when it comes in the way.

The seeds of a multitude of plants which have no apparent useful function except to increase by their decay the deposit of humus in the soil constitute the staff of life of the quail. In this particular investigation they aggregate 62.5 per cent of the food of the year. They appear in stomachs taken in every month and reach a good percentage in each, the only months that show much diminution in quantity being January, February, March, and April, when new forage partly replaces seeds. The percentage is highest in June, 85.9, but shows no great falling off from July to December, inclusive. Seventy-three kinds of seeds were identified, at least generically, and more than half of them were determined specifically. Many more were ground up so as to be unrecognizable.

Bur thistle, lupines, bur clover, and turkey mullein appear to be the favorite seeds; that the others are not distasteful is shown by the quantities found in some stomachs. For instance, mayweed was identified in only 27 stomachs, yet one stomach contained at least 2,000 of these seeds; pigweed (*Chenopodium*) in but 11, yet 1 contained 1,000. One stomach held 83 kernels of barley, 592 seeds of geranium, 560 of tarweed, 40 of bur thistle, 48 of clover, 80 of alfilaria, 704 of timothy, 32 of catchfly, and 5 of snowberry, or 2,144 seeds in all. Another contained 1,696 geranium seeds, 14 bur thistle, 24 knotweed, 14 tarweed, 38 bur clover, 148 alfilaria, 12 ray grass, and 1 unknown seed, and a pod of uncertain origin—in all, 1,947 seeds and a pod. In both cases the contents of the crop is included with that of the stomach or gizzard. These samples indicate considerable variety in the quail's diet, even in one meal.

---

[1] Zoe, IV, pp. 55–56, 1893–94.

Grass and other forage constitute a little over 25 per cent of the quail's annual food. Forage amounts to less than 1 per cent in June, remains about the same until October, and increases somewhat in November. In January it becomes important, and it reaches nearly 60 per cent of the food for the next four months. The maximum, 85 per cent, occurs in March; but this percentage, based on only one stomach, can not be considered final. Seeds and forage are practically complementary to each other; that is, as one increases the other decreases. June, which shows the least forage, has the largest percentage of seeds. Leaves of red and of bur clover and of alfilaria were the favorite kinds, and in some cases constituted the whole stomach contents. Blades of grass are frequently taken. A few bits of acorn, and perhaps other nuts, were eaten, but the quantity is insignificant.

Summary.—From the above analysis of the food of the California quail it is apparent that under normal conditions the farmer and fruit grower have nothing to fear from its ravages. When, however, large areas of chaparral land are cleared and brought under cultivation, it is natural that the products of garden and vineyard should be eaten to a greater or less extent by quail, which abound in such localities. On the other hand, its seed-eating record is in its favor. Usually there is little difficulty in getting rid of a superfluity of game birds; in fact, in most cases the trouble is to prevent their extermination. This is strikingly illustrated by the fact that, in order to restock its depleted covers, an attempt is now being made in southern California to import quail from the peninsula of Lower California. A bird so large, so easily trapped, so valuable for food, and withal one whose pursuit affords such excellent sport as the valley quail, will rarely become numerous enough to do serious damage, and then only locally and under unusual conditions. When such conditions arise, a reduction of numbers is the easiest and simplest cure, and in California this usually can be accomplished through the State board of fish and game commissioners. After the numbers have been sufficiently reduced the birds can be kept within reasonable limits by a moderate amount of shooting in the proper season.—F. E. L. B.[1]

---

[1] Prof. F. E. L. Beal died on October 1, 1916.—EDITOR.

RUFFED GROUSE.

(*Bonasa umbellus.*)

The ruffed grouse (fig. 3), called "partridge" in the northeastern States and pheasant in some other parts of its range, is one of our most widely ranging game birds. It inhabits wooded regions from Canada and Alaska south to California, Colorado, Tennessee, and northern Georgia. It is usually a wild and wary bird and well withstands the attacks of hunters, but it responds to protection in a gratifying manner and has proved to be well adapted to propagation under artificial conditions. On account of these qualities and its desirability as a game species it is a good subject for game farming.

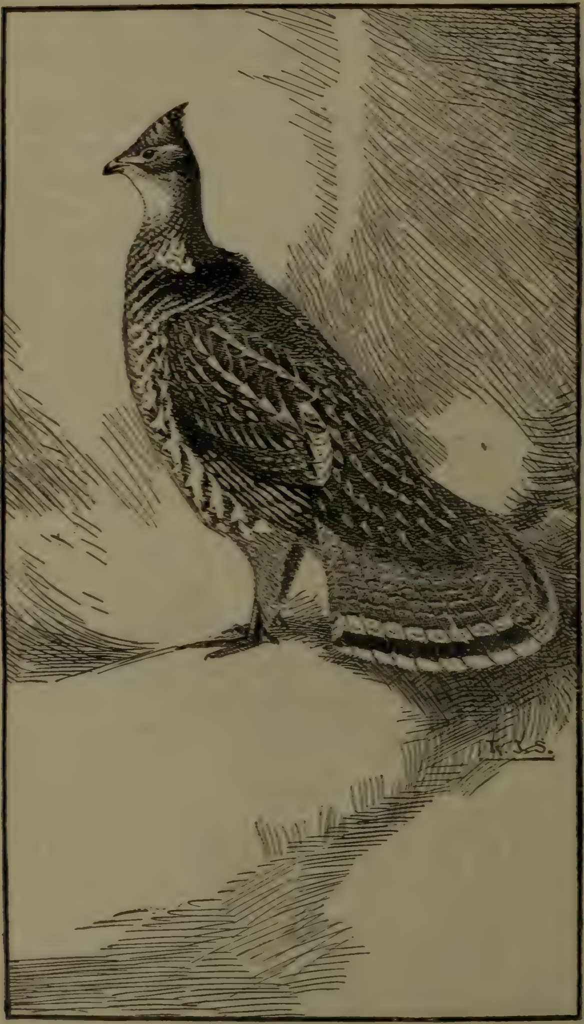


Fig. 3.—Ruffed grouse.

Wild fruits, mast, and browse make up the bulk of the vegetable food of this species. It is very fond of hazelnuts, beechnuts, chestnuts, and acorns and it eats practically all kinds of wild berries and other fruits. Nearly 60 kinds of fruits have been identified from the stomach contents examined. Various weed seeds are also consumed.

Slightly more than 10 per cent of the food consists of insects, about half of which are beetles. The most important pests devoured are the Colorado potato beetle, clover-root weevil, the pale-striped flea beetle, grapevine leaf-beetle, May beetles, grasshoppers, cotton worms, army worms, cutworms, the red-humped apple caterpillar, and sawfly larvæ.—W. L. M.

INTRODUCED PHEASANTS.

(*Phasianus torquatus and P. colchicus.*)

While introduced pheasants may hardly seem to deserve a place on a list of common birds, the extent to which they are being imported and propagated in the United States makes it desirable that information be made available as to their feeding habits when liberated. Ringneck pheasants (fig. 4) have long been established in Oregon, Washington, and British Columbia, and are less common in the wild state in Massachusetts, New York, Indiana, and Kansas. But persistent efforts, in some cases on a very large scale, are being made to establish pheasants in other States, and the farmers whose land they are likely to range over should have access to information concerning their economic value.

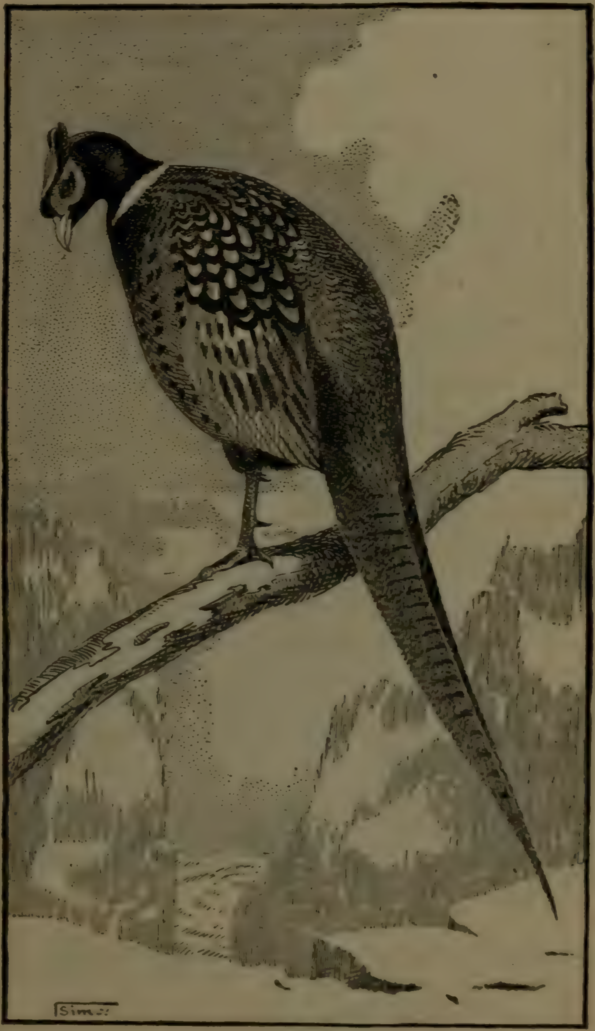


FIG. 4.—Ringneck pheasant.

Severe criticism of pheasants and fulsome praise are about equal in volume. The birds are accused of digging newly planted and sprouting corn, oats, barley, and beans, and seeds of melons, cucumbers, and squashes. It is claimed that because of their depredations it has been necessary to replant whole fields of corn. They are said to drive chickens away from their food and even to kill young poultry. Some landowners in Ontario County, N. Y., claim that the loss suffered on account of pheasants has been more than twice the amount of their taxes.

On the other hand the birds have not proved a nuisance in Oregon and Washington, where they have been numerous for years. Some farmers even value them so highly that they will not permit hunting on their property.

The few pheasant stomachs examined indicate that these birds are very fond of grain. Oats and wheat compose about 34 per cent of the food of 12 ringneck pheasants collected in Oregon and Washington, and 82.5 per cent of the stomach contents of two English pheasants from British Columbia. But all of these birds were taken in September, October, and December; hence it is probable that all of this grain was waste. The next largest item of food in these stomachs was insects, consisting entirely of larvæ of March flies (*Bibio*). One stomach contained no fewer than 360 of these larvæ and another 432. The remainder of the food included acorns, pine seeds, browse, peas, rose hips, snowberries, and seeds of dandelion, lupine, bur clover, black mustard, and chickweed.

From 200 to 960 kernels of wheat and oats were taken by various birds; about 200 peas were found in one stomach, but it was evident that these were the old and partly decomposed refuse of the harvest. Twenty-three acorns and 200 pine seeds were taken by the bird which ate the largest amount of mast, and about 800 capsules of chickweed, containing more than 8,000 seeds, were in the stomach of the best weed-seed eater.

What is most evident is that pheasants are gross feeders; their capabilities for good or harm are great. If a number of them attack a crop they are likely to make short work of it, or if they devote themselves to weed seeds or insect pests they do a great deal of good. It seems therefore that the question of the economic value of pheasants is peculiarly a local one. Much depends on the proportion of land under cultivation, the kind of crops raised, and the quantity of wild food available. Apparently the chances are about even that imported pheasants will or will not become useful economic factors.—W. L. M.

UPLAND PLOVER.

(*Bartramia longicauda.*)

The upland plover (fig. 5) forms a striking exception in habits to its closest relatives, the sandpipers. While sandpipers love the vicinity of water, the upland plover frequents dry hills and prairies and is most abundant in the interior. This so-called plover breeds from Oregon, Oklahoma, and Virginia north to Alaska, Mackenzie, and Maine, and migrates over the more southern parts of the continent, passing to the pampas of Argentina to spend the winters.

From its habits the upland plover would naturally be expected to have a closer relation to agriculture than most sandpipers, and such proves to be the case. Almost half its food is made up of grasshoppers, crickets, and weevils, all of which exact heavy toll from cultivated crops. Among the weevils eaten are the cottonboll weevil; greater and lesser clover-leaf weevils; clover-root weevil; *Epicærus imbricatus*, which is known to attack almost all garden and orchard crops; cowpea curculios; *Tanymecus confertus*, an enemy of sugar beets; *Thecesternus humeralis*, which has been known to injure grapevines; and bill bugs. *Thecesternus* alone composes 3.65 per cent of the seasonal food of the 163 stomachs examined, and bill bugs constitute 5.83 per cent. No fewer than 8 species of bill bugs were identified from the stomachs. These weevils injure, often seriously, such crops as corn, wheat, barley, and rye, as well as forage plants of many kinds.

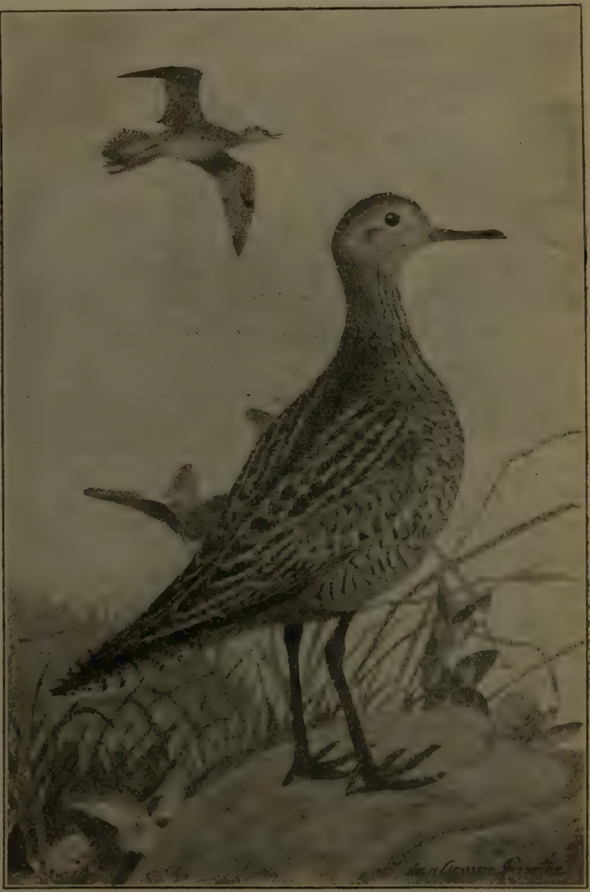


FIG. 5.—Upland plover.

The upland plover further makes itself useful to the farmer by devouring leaf-beetles, including the grapevine colaspis, southern corn leaf-beetle, and other injurious species; wireworms and their adult forms, the click beetles; white grubs and their parents, the May beetles; cutworms, army worms; cotton worms; cotton cutworms, sawfly larvæ; and leatherjackets or cranefly larvæ. They befriend cattle by eating horseflies and their larvæ, and cattle ticks.

They eat a variety of other animal forms, such as moths, ants, and other Hymenoptera, flies, bugs, centipeds and millepeds, spiders, snails, and earthworms. Practically 97 per cent of the food consists of animal matter, chiefly of injurious and neutral forms. The vegetable food comprises the seeds of such weed pests as buttonweed, foxtail grass, and sand spurs, and hence is also to the credit of the bird.

Notwithstanding that the upland plover injures no crop and consumes a host of the worst enemies of agriculture, it is one of the numerous shore birds that have been hunted to the verge of extinction. Can it be that the American public will allow one of the best friends of agriculture to be exterminated by hunters who care only for the momentary excitement of dropping these swiftly flying birds and the pleasure of devouring the few mouthfuls of savory flesh they afford?—W. L. M.

KILLDEER.

(*Oxyechus vociferus.*)

The killdeer (fig. 6) is one of the best known American birds. It frequents cultivated lands and even roads and the vicinity of buildings. It is well named "vociferus," for it delights in repeating the loud and penetrating call of "kill-dee, kill-dee," from which its common name is taken. The killdeer nests throughout the United States and southern Canada. Some individuals spend the winter in the southern half of the United States or occasionally even farther north, while others go as far south as northern South America.

Like the upland plover the killdeer spends much of its time away from water. It frequently nests in cornfields or pastures and, as noted above, even comes about the abode of man. These preferences naturally influence the food habits of the species, affording it an opportunity to destroy insects which are directly related to agriculture. The food of the killdeer is varied, being composed of the following principal items: Beetles, 37.06 per cent; other insects, as grasshoppers, caterpillars, ants, bugs, caddis flies, dragon flies, and two-winged flies, 39.54 per cent; and other invertebrates, as centipeds, spiders, ticks, oyster worms, earthworms, snails, crabs, and other crustacea, 21.12 per cent. Vegetable matter composes 2.28 per cent of the total food, and is chiefly made up of weed seeds, such as buttonweed, smartweed, foxtail grass, and nightshade.

Among the injurious beetles consumed are the following weevils: Alfalfa weevil, cotton-boll weevil, clover-root weevil, clover-leaf weevil, rice weevil, cowpea curculio, white-pine weevil, and bill bugs. The latter alone constitute more than 2 per cent of the whole food. The alfalfa weevil, a new and destructive pest, is relished by the killdeer, 41 being found in a single stomach. Other destructive beetles devoured are white grubs and their adult forms, the May beetles; wireworms and their imagos, the click beetles; larvæ of the genus *Ligyrus*, which attack sugar cane, corn, and carrots; brown-fruit beetles, which injure apples and corn; the grapevine leaf-beetle; southern corn-leaf beetle; two-striped tortoise beetle, which injures sweet potatoes; and a flea beetle which attacks tobacco and sugar beets.

Cicadas, buffalo tree hoppers, and negro bugs, the last named injuring parsley and raspberries, are some of the true bugs relished by the killdeer. Caterpillars are a favorite article of diet, and several very injurious species are eaten, as the cotton worm, cotton cutworm, other cutworms, and caterpillars of the genus *Phlegethontius*, which damage tomatoes and tobacco. Grasshoppers and crickets, including mole crickets, are a staple food. Two-winged flies or Diptera furnish 11.91 per cent of the food of the killdeer. Such pests as crane flies and their larvæ, known as leatherjackets, are eaten, as well as horseflies and mosquitoes and their larvæ. One stomach contained hundreds of larvæ of the salt marsh mosquito (*Aëdes sollicitans*), which is one of the most troublesome of the biting species. The State of

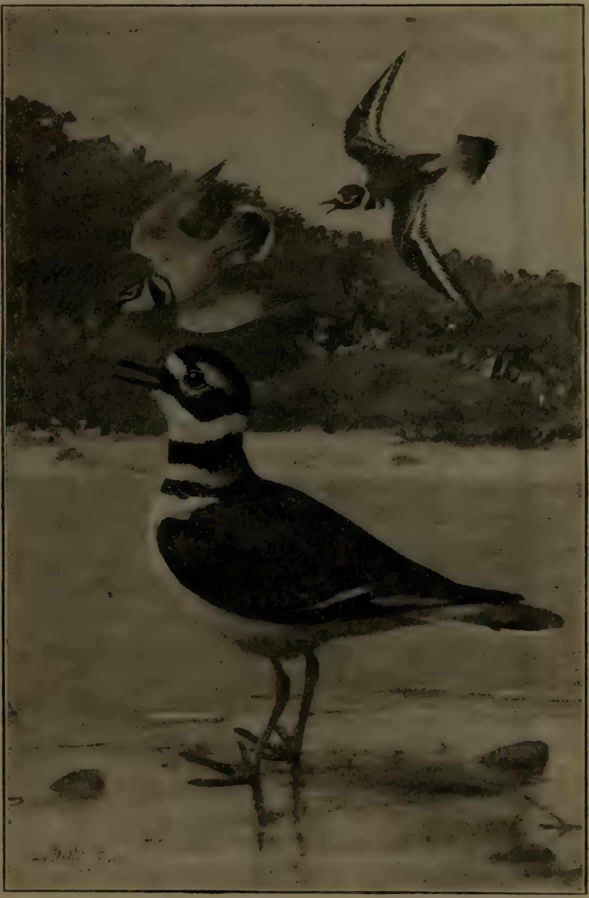


FIG. 6.—Killdeer.

New Jersey has spent thousands of dollars in trying to reduce the numbers of this pest. The killdeer thus befriends man, but it does something also for the domestic animals, not only by eating horseflies and mosquitoes, as just mentioned, but also by preying upon ticks, including the American fever or cattle tick, which has caused such enormous losses in some parts of the South.

Crawfish, well-known pests in levees, and even in corn, cotton, and other fields in certain localities, are another item of the killdeer's food, and 3.62 per cent of the subsistence of the 228 birds examined was composed of worms of the genus *Nereis*, which prey upon oysters.

In all, 97.72 per cent of the killdeer's food is composed of insects and other animal matter. The bird preys upon many of the worst crop pests and is a valuable economic factor. There can be no logical reason for continuing to regard it as a game bird.—W. L. M.

HORNED GREBE.

(*Colymbus auritus.*)

Grebes are among the most interesting of water birds. Their power of diving as quick as a flash or of sinking beneath the surface without leaving a ripple has earned for them such names as hell-diver, sprite, and water witch. Grebes are not only accomplished divers, but swim well under water for long distances—not exclusively by aid of the feet, however, as is often stated. The writer has more than once seen the pied-bill grebe using its wings in underwater progression. Grebes have difficulty in rising from the water, but fly well when under way. When alighting they strike the water with a splash, gliding some distance on the breast. The nests are built of water-soaked vegetation, a portion of which is used to cover the eggs in the absence of the parents.

To illustrate the food habits of grebes, the horned grebe (fig. 7) is chosen. This species has a circumpolar range. In North America it breeds from the northern tier of the United States northward, and winters from the southern boundary of the breeding range south to Florida and California. The most remarkable point about the food habits of grebes is that the stomachs almost invariably contain a considerable mass of feathers. Feathers are fed to the young, and there is no question that they play some essential though unknown part in the digestive economy. As they are finely ground in the gizzards it is probable that finally they are digested and the available nutriment assimilated. Feathers constituted practically 66 per cent of the contents of the 57 horned grebe stomachs examined. However, it is not likely that they furnish a very large percentage of the nourishment needed by the birds. As the nutritive value of the feathers is unknown, this part of the stomach contents is ignored.

The other items of food are assigned 100 per cent, and the percentages are given on that basis. Various beetles, chiefly aquatic, compose 23.3 per cent of the food; other insects (including aquatic bugs, caddis and chironomid larvæ, dragon-fly nymphs, etc.), nearly 12 per cent; fishes, 27.8 per cent; crawfish, 20.7 per cent; and other crustacea, 13.8 per cent. A little other animal matter is taken, including snails and spiders, and a small quantity of vegetable food was found in two stomachs.

It has been claimed that grebes live exclusively on fishes and do mischief in fish hatcheries. The results obtained by stomach examinations show that they do not depend wholly or even chiefly upon fish. On the contrary, they eat a large number of crawfishes, which often severely damage crops, and consume numbers of aquatic insects which devour small fishes and the food of such fishes.—W. L. M.

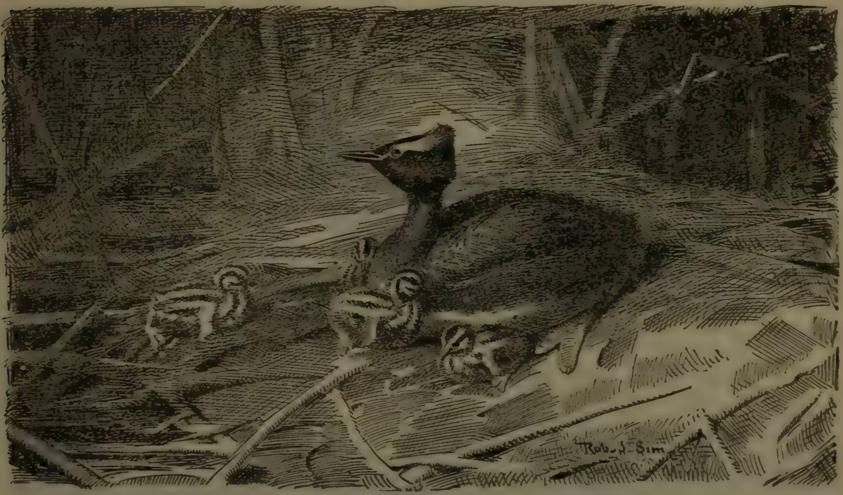


FIG. 7.—Horned grebe.

FRANKLIN'S GULL.

(*Larus franklini.*)

The term "gull" usually suggests a vision of dashing spray or far-extending beaches with reedy bays and outreaching points of sand or islets on which the birds rest to preen their feathers after their long flights, and on which perchance they make their nests and rear their young. Unlike most gulls, however, Franklin's gull (fig. 8) spends little time on the seacoast but is an inhabitant of far-inland prairies and broad reaches of marsh land, where it lives and breeds during the warm season. In winter it retires southward, but lingers long enough in some of the Southern States to be of material assistance to agriculture. During the breeding season it occupies the region described by Minnesota, North and South Dakota, and the southern parts of Manitoba, Saskatchewan, and Alberta. The marshy lakes of this region afford ideal nesting sites for the species, while the adjoining broad stretches of prairie land yield an abundance of their favorite food. A few decades ago these birds occupied this vast region undisturbed, but to-day the plow is turning up the sod and the mower cutting the grass of the boundless fields over which for centuries they have foraged. With the advent of agricultural operations some changes harmful to the birds must necessarily take place, but it behooves the tillers of the soil to leave the gulls unmolested as far as possible, for where they abound they are a most potent factor in the reduction of insect life. They do not by any means confine themselves to marshes when seeking for food, but fly over the dry prairie and even visit cultivated fields, looking for grubs, grasshoppers, and other insects. When unmolested they become quite fearless and follow the plowman to gather the grubs and worms from the newly turned furrows.

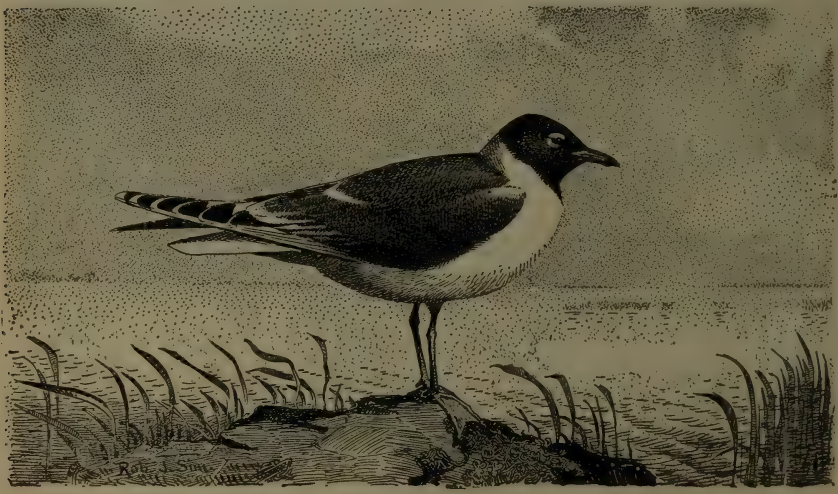


FIG. 8.—Franklin's gull.

In an investigation of the food of Franklin's gull 93 stomachs were examined. Nearly all were taken from their breeding grounds and in the breeding season.

Of the whole food 94.46 per cent consisted of animal matter and 5.54 per cent of vegetable. Of the latter nearly all was of no significance, probably being taken accidentally, except the contents of

2 stomachs collected in May in North Dakota. About 75 per cent of the contents of each of these consisted of wheat probably gathered from newly sown fields. This was the only vegetable food found in any stomach that was of the least economic value.

Of the animal food the most important item is grasshoppers. These amount to 43.43 per cent of the food of the season, and in September and October constitute over four-fifths of the whole diet. As an example of the number these birds can eat at a single meal, the following may be cited. Stomach A contained 70 entire grasshoppers and jaws of 56 more, with remains of 3 crickets. Stomach B contained 20 beetles, 66 crickets, 34 grasshoppers, and 3 other insects. Stomach C contained 90 whole grasshoppers, the jaws of 52 more, with 8 crickets, 1 bug, and 1 caterpillar. Stomach D contained 82 beetles, 87 bugs, 984 ants, 1 cricket, 1 grasshopper, and 2 spiders, or 1,157 insects in all. Stomach E was filled with 327 nymphs of dragon flies. Several other stomachs were completely filled with grasshoppers and crickets, too far advanced in digestion to be counted. Adults and larvæ (grubs) of May beetles were also a large component of the food and these were probably taken upon cultivated ground. Stomachs collected in Louisiana during the fall migration contained in addition to grasshoppers and beetles large numbers of true bugs (Hemiptera), including several species which are injurious to cotton, tobacco, and squashes. From this brief statement of the food of Franklin's gull, farmers will readily perceive that these birds are very desirable neighbors and will do all in their power to protect them.

There are several other species of gulls and terns that, like Franklin's, take up their residence about the lakes and marshes in the interior of the country. Their food habits, as far as known, are all beneficial to the farmer. They are great eaters of grasshoppers and have been seen catching those insects on the wing and also may often be seen following the plow in search of the grubs and beetles turned up. Among these are the California gull (*Larus californicus*), the ring-billed gull (*Larus delawarensis*), and the black tern (*Hydrochelidon nigra surinamensis*). The latter lives and breeds about marshes where there is often little or no open water.

An illustration of the value of gulls as insect destroyers is furnished by the experience of the Mormons when they settled in Utah and raised their first crops of grain. This is graphically described by Hon. Geo. A. Cannon, temporary chairman of the Third Irrigation Congress:

> Black crickets came down by millions and destroyed our grain crops; promising fields of wheat in the morning were in the evening as smooth as a man's hand—devoured by the crickets. At this juncture sea gulls [California gulls] came by hundreds and thousands, and before the crops were entirely destroyed these gulls devoured the

insects, so that our fields were entirely freed from them. The settlers at Salt Lake regarded the advent of the birds as a heaven-sent miracle. * * * I have been along the ditches in the morning and have seen lumps of these crickets vomited up by these gulls, so that they could again begin killing.

These "lumps of crickets" were undoubtedly "pellets" of the indigestible parts habitually disgorged by the birds. At the time of the Nevada mouse plague in Humboldt Valley in 1907, gulls, as well as hawks and owls, were noted feasting on the destructive rodents.—F. E. L. B.

TERNS.

Like the gulls, terns are usually associated in the mind with the seacoast, but at least six species breed in the interior of the continent. The terns are expert in flight, and so trim and graceful in appearance that they have received the name sea swallows. They breed in colonies, usually nesting on low islands. This leads to the destruction of large numbers of eggs and young by high tides. Formerly terns were slaughtered for millinery purposes to such an extent that some species have been almost extirpated.

Persons engaged in the plumage business have made the not disinterested charge that terns devour large numbers of food fishes and hence should be destroyed. In order to ascertain the truth of the matter the Biological Survey has made a thorough examination of the question. Too few stomachs of the caspian, roseate, and arctic terns have been examined to form a basis for satisfactory conclusions, but a fair number of stomachs of five other species were available—the royal tern, Forster's tern, common tern, least tern, and black tern.

Royal tern (*Sterna maxima*).—Twenty-four stomachs were examined. They contained 3 per cent of crustacea and 97 per cent of fish. The fishes were yellow perch (*Perca flavescens*), 4 per cent, taken in North Carolina in July; bluefish (*Pomatomus saltatrix*), 8 per cent, taken in Florida in March; menhaden (*Brevoortia tyrannus*), 65 per cent, taken in Georgia in November and December, Alabama in October, and Florida in February, August, October, November, and December; and unidentified fishes, 20 per cent.

Thus it is probable that not more than 16 per cent of the normal food consists of fishes eaten by man. The feeding upon menhaden, tons of which are made into fertilizer, is insignificant economically.

Forster's tern (*Sterna forsteri*).—The food of 34 specimens of this species consisted of crustacea, 2 per cent, and fish, 98 per cent. The largest item of finny food was menhaden (*Brevoortia tyrannus*), 28.2 per cent, found in stomachs taken in South Carolina, Georgia, and Florida in November, December, and January, respectively. Silvery anchovies (*Stolephorus*) (not the anchovies of commerce), forming 24.1 per cent, were next in rank. They were taken in California in September and December, and in Georgia and Florida in November, December, and January. Fresh-water minnows (Cyprinidæ) composed 20.5 per cent of the food. Following these in importance were pompanos (*Trachinotus carolinus*), 5.9 per cent; round herrings (*Etrumeus sadina*), 5.8 per cent; mummichogs (*Fundulus zebrinus*) and fresh-water sticklebacks (*Eucalia inconstans*), 2.6 per cent each. Unidentified fish made up 7.3 per cent of the food.

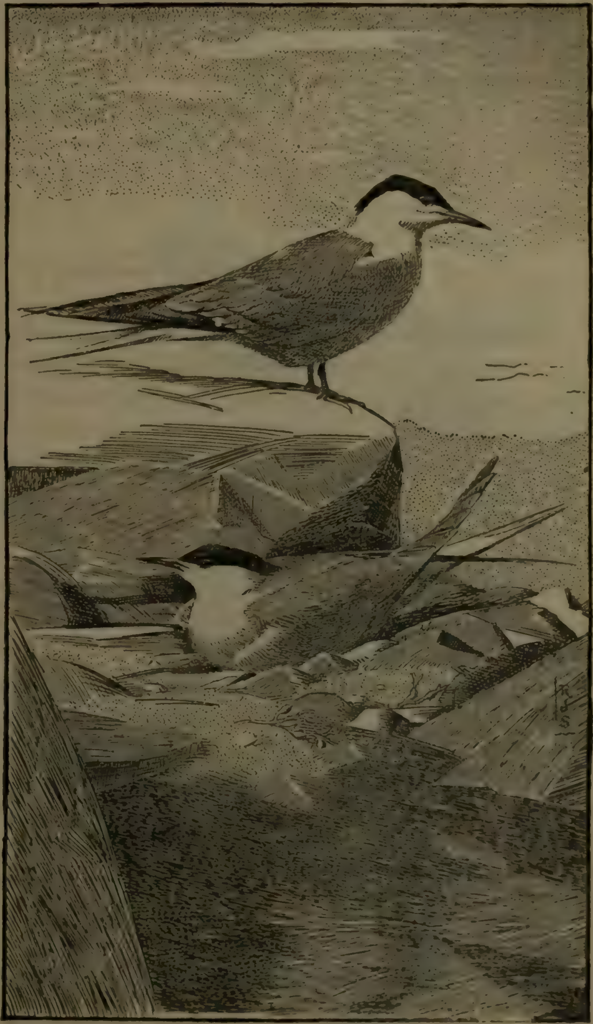


FIG. 9.—Common tern.

Thus only 5.9 per cent of the food of Forster's tern, as at present known, consists of food fishes; 92 per cent consists of fishes of no direct value to man, among which are sticklebacks, which feed upon the spawn of other fishes.

Common tern (*Sterna hirundo*).—One hundred and sixteen stomachs of the common tern (fig. 9) have been examined. One per cent of their food consists of mollusks, crustacea, and the worms (*Nereis*) which feed upon oysters. Two per cent is composed of moths and 1.5 per cent of other insects, including grasshoppers, crickets, ants, dragon flies, caddis flies, beetles, and bugs. The remaining 95.5 per cent consists of fishes. The largest item is fresh-water minnows (Cyprinidæ), 23.3 per cent. Sand launces (*Ammodytes americanus*) make 17.8 per cent of the food. Other fishes eaten are menhaden (*Brevoortia tyrannus*), 5.1 per cent; yellow perch (*Perca flavescens*) and sticklebacks (*Gasterosteus bispinosus*), 4.3 per cent each; and silvery anchovies (*Stolephorus*), chub mackerel (*Scomber colias*), and silversides (*Menidia*), 1 per cent each.

Only 6 per cent of the bird's food is composed of food fishes. To offset this, 3.5 per cent consists of insects, mostly injurious, and 4.3 per cent of sticklebacks, of which a distinguished naturalist (Günther) says: "It is scarcely to be conceived what damage these little fishes do, and how greatly detrimental they are to the increase of all the fishes among which they live, for it is with the utmost industry, sagacity, and greediness that they seek out and destroy all the young fry that come their way."

Almost 85 per cent of the food consists of fishes of neutral importance.

Least tern (*Sterna antillarum*).—Almost half (43.1 per cent) of the food of 49 least terns consists of silver anchovies (*Stolephorus*). They were captured from New Jersey to Florida and Louisiana in May and June. Menhaden (*Brevoortia tyrannus*) compose 6.8 per cent; mummichogs (*Fundulus*), 6.3 per cent; silversides (*Menidia*), 1.1 per cent; and unidentified fish, 37.7 per cent. The remaining 5 per cent of the food is made up of crustacea. No food fishes were identified from stomachs of the least tern.

Black tern (*Hydrochelidon nigra surinamensis*).—The food of the black tern (fig. 10) is more varied than that of any other species. Fish, chiefly minnows (Cyprinidæ) and mummichogs (*Fundulus*), compose a little more than 19 per cent of the total contents of 145 stomachs. Dragon flies make more than 20 per cent; May flies, 13 per cent; grasshoppers, 12 per cent; predaceous diving beetles, almost 6 per cent; scarabæid beetles, almost 5 per cent; leaf beetles, 3½ per cent; gnats and other flies, more than 8 per cent; crustacea, 3½ per cent. Other items of food are ground-beetles (Carabidæ), click beetles (Elateridæ), weevils, stone flies, caddis flies, water striders, moths, and ants.

The bird preys upon no food fishes, as far as known, but does feed extensively upon such fish enemies as dragon-fly nymphs, dytiscid beetles, and crawfishes. It takes a great variety of insects, including some of economic importance, as the moth of the cotton bollworm and the fall army worm, click beetles (adults of wireworms), weevils, and grasshoppers.

Summary.—The average percentage of food fishes in the regimen of these five species of terns is only 4.8 per cent. This refutes the charge that they live largely on food fishes. Among the other fishes eaten, menhaden are prominent, forming an average of 21 per cent of the food. Since these fish are so enormously abundant that their chief economic value is for fertilizer and oil, hundreds of tons of which are made, the number of them consumed by terns is insignificant. Silvery anchovies (*Stolephorus*) and fresh water minnows (Cyprinidæ) compose about 13 per cent each. These little fishes swarm in shallow waters and are of no direct value to man.

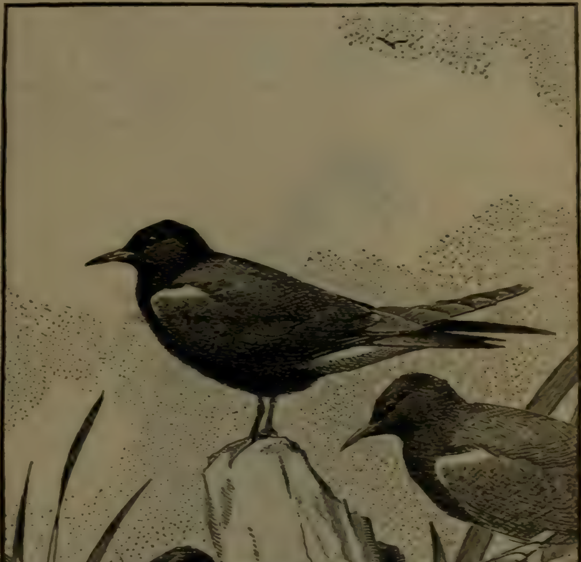


FIG. 1[illegible].—Black tern.

The charge that terns prevent the increase of food fishes by eating the small fishes which are their natural food is wholly unfounded, since there is no scarcity in the food supply, but on the contrary a constant superabundance. In this connection we would point out that some largely herbivorous food fishes, such as the buffalo fishes, with whose food supply the terns have very little to do, have alarmingly decreased, just as have some of the carnivorous ones. The cause of reduction in the number of food fishes is not chiefly failure of the natural food supply, but, as has been pointed out by experts of the United States Bureau of Fisheries, too close fishing.

The responsibility for the scarcity of certain food fishes, therefore, can not justly be placed upon the terns, especially since it is shown that a very small proportion of their diet is composed of these fishes.

Moreover, it must be remembered to their credit that part of their food consists of economically injurious fishes, and that in the case of some species a considerable proportion of insects is taken, most of which are directly injurious to the fishing industry.—W. L. M.

COOPER'S HAWK.

(*Accipiter cooperi.*)

Cooper's hawk (fig. 11) may be taken as a type of the group of hawks whose habits are responsible for the condemnation of birds of prey as a whole. This group includes three species: Cooper's hawk, the sharp-shinned hawk, and the goshawk. They are often spoken of as blue darters, a name which expresses a characteristic difference in their manner of hunting from that of other hawks. They course over the country at great speed and capture their prey by sudden darts. The blue darters are long-tailed hawks, but they should not be confounded with that other conspicuously long-tailed bird, the marsh hawk. The latter usually flies slowly and may be recognized by the white rump. The red-tailed,[1] red-shouldered, and other large hawks usually watch for their prey from some convenient lookout station or soar slowly over meadow and forest, watching a chance to pounce upon their quarry. These hawks almost always seize their victims on the ground, while hawks of the darter group often take them in full flight. This difference is of course chiefly due to the character of the prey, the darters feeding almost exclusively upon birds, which usually must be caught on the wing, while the other hawks prey upon

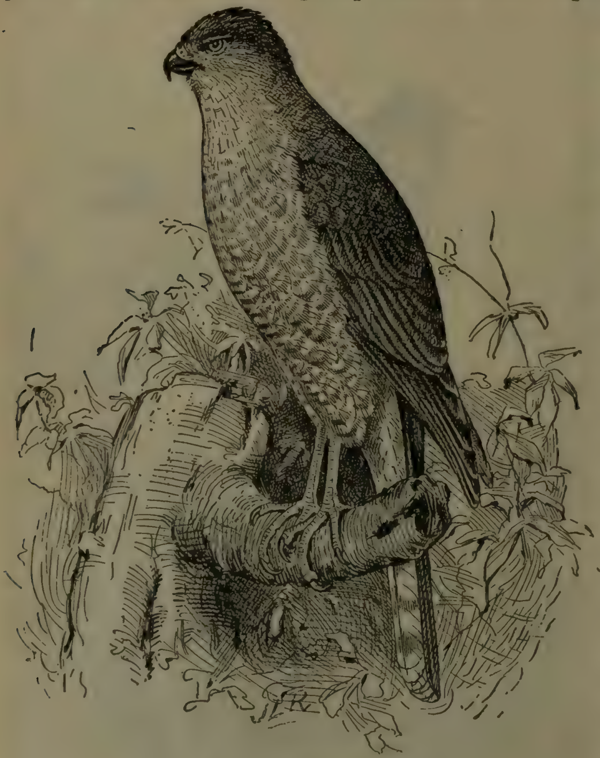


FIG. 11.—Cooper's hawk.

---

[1] Red-tailed hawk (*Buteo borealis*). See illustration on title-page.

mice and other small mammals, snakes, and grasshoppers and other insects, which as a rule must be sought on the ground.

Cooper's hawk, which occurs throughout the United States, is preeminently a "chicken hawk," and it is by far the most destructive species we have to contend with, not because it is individually worse than the goshawk, but because it is so much more numerous that the aggregate damage done far exceeds that of all other birds of prey. It is strong enough to carry away a good-sized chicken, grouse, or cottontail rabbit. It is especially fond of domesticated doves and when it finds a cote easy of approach it usually takes a toll of one or two a day. Practically every stomach of Cooper's hawk examined contained remains of wild birds or poultry.—W. L. M.

THE ROUGH-LEGGED HAWK.

(*Archibuteo lagopus sancti-johannis.*)

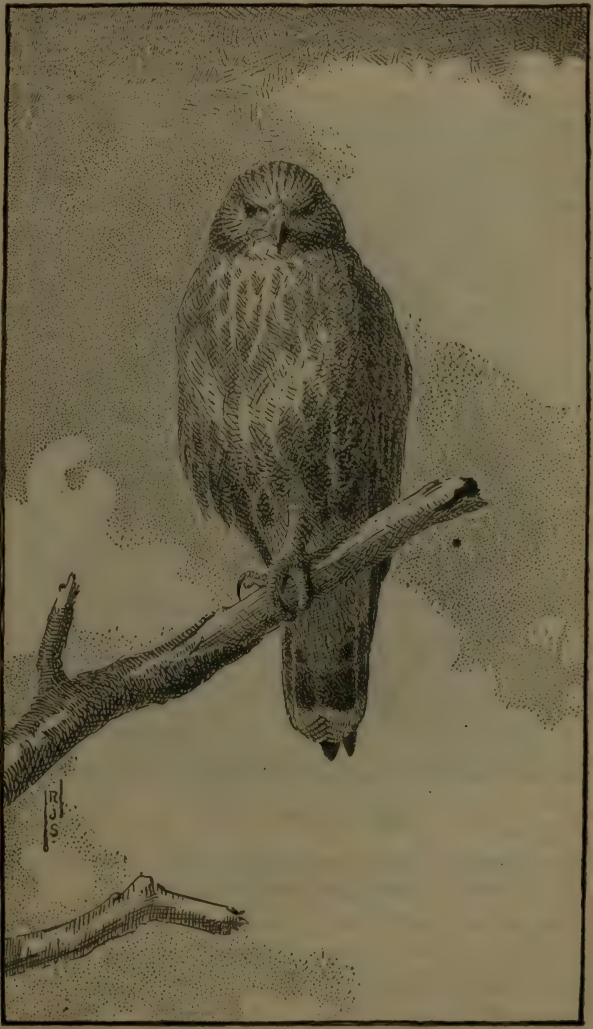


FIG. 12.—Rough-legged hawk.

The rough-legged hawk (fig. 12), whose range, in general terms, is North America north of Mexico, is a representative of the class of almost wholly beneficial hawks. In regard to its habits Dr. Fisher says:

The rough-leg is one of the most nocturnal of our hawks, and may be seen in the fading twilight watching from some low perch, or beating with measured, noiseless flight, over its hunting ground. It follows two very different methods in securing its food, one by sitting on some stub or low tree and watching the ground for the appearance of its prey, as the red tail does; the other by beating back and forth just above the tops of the grass or bushes, and dropping upon its victim after the manner of the marsh hawk. Its food consists principally, if not almost exclusively, of the smaller rodents, and most prominent among these are the arvicoline mice and lemmings. As is well known, the meadow mice (*Arvicolæ*) are widely distributed over the north temperate zone, and often occur in immense numbers, overrunning certain sections of country, and doing irreparable damage to crops as well as to fruit and ornamental trees. Repeatedly young orchards, consisting of hundreds of trees, and representing great money value, have been totally destroyed by these pests. The damage is done in winter, under the snow, where the mice eat the bark from the trees, often completely girdling them and causing death. Usually meadow mice are fairly common if not abundant over a large part of the meadow and marsh lands of the central and northern United States and temperate Canada. To show how important meadow mice are to the rough leg as an article of food, it may be stated in general terms that the southern limit of its wandering in winter is nearly coincident with the southern boundary of the region inhabited by meadow mice. In the north lemmings are abundant over the country in which the rough leg makes its summer home, and furnish a never-failing supply of food for old and young.[1]

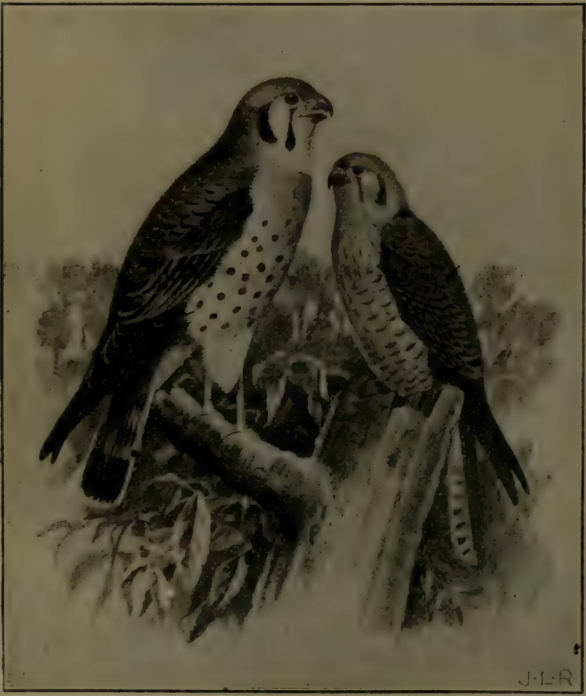


FIG. 13.—Sparrow hawk.

Meadow mice were found in 28 stomachs, 5 or 6 occurring in several, and as many as 12 in 1. A few rats, house mice, shrews, and other small mammals also were found, birds appearing in only 3 stomachs.—W. L. M.

SPARROW HAWK.

(*Falco sparverius.*)

The sparrow hawk (fig. 13) ranges over almost the whole of North America. It is the smallest as well as one of the handsomest of our hawks and one of the best known. It is further distinguished by its swallowlike flight, its habit of hovering over the luckless grasshopper or meadow mouse it hopes to make a meal of, and its repeated shrill wavering cry. "It is the only one of the true falcons," as has been pointed out by Dr. Fisher, "which can be placed in the mainly beneficial class." He says further:

---

[1] Bull. 3, Biological Survey, p. 87, 1893.

> At times it attacks small birds and young chickens, but these irregularities are so infrequent that they are more than outweighed by its good services in destroying insects and mice. Grasshoppers, crickets, and other insects form its principal food during the warm months, while mice predominate during the rest of the year. Terrestrial caterpillars, beetles, and spiders also are eaten to a considerable extent. As might be expected, a large proportion of the birds captured are taken during the nesting season, the hawks then having less time to secure their favorite food. It is at this time also that they commit depredations in poultry yards. During late fall and winter, meadow mice and house mice form a large part of their food, the former being taken in fields and meadows and the latter around corn stacks and about barns and outbuildings. Because of its confidence and lack of fear the sparrow hawk is one of the species which suffers most from unjust bounty laws. Any vandal who can carry a gun is able to slaughter this little hawk. Mr. W. B. Hall, of Wakeman, Ohio, writes us that while the hawk law was in force in Ohio he was township clerk in his native village and issued 86 certificates, 46 being for sparrow hawks. He examined the stomachs and found 45 of them to contain the remains of grasshoppers and beetles, while the remaining one contained the fur and bones of a meadow mouse.[1]

W. L. M.

LONG-EARED OWL.

(*Asio wilsonianus.*)

The long-eared owl occurs throughout the United States. It is nocturnal in its habits and is one of our most beneficial species. Mice, principally meadow mice, are its staple food. One hundred and fifty pellets collected by Dr. Fisher under the roost of a bird of this species at Munson Hill, Va., contained remains of 95 meadow mice, 19 pine mice, 15 house mice, 5 white-footed mice, 3 Cooper's mice, 26 shrews, and 13 birds, of which 11 were sparrows, 1 a bluebird, and the other a warbler. Eighty-six out of 92 stomachs examined also contained mice. The bird is common all over the United States and does a great deal of good. It is not wary, hence is one of the greatest sufferers where bounties are paid for the destruction of birds of prey.—W. L. M.

SCREECH OWL.

(*Otus asio.*)

The little screech owl (fig. 14), in the South aptly called "shivering owl," in allusion to its quavering whistle, or perhaps to the effect of that call upon the listener, ranges from coast to coast and far beyond both the northern and southern boundaries of the United States. With the exception of the burrowing owl it feeds more extensively on insects than any of the other owls. It is also, according to Dr. Fisher—

---

[1] Circ. 61, Biological Survey, p. 9, 1907.

> a diligent mouser, and feeds more or less on crawfish, frogs, toads, scorpions, lizards, and fish. * * * Among insects, grasshoppers, crickets, beetles, and cutworms are most often eaten. As many as 50 grasshoppers have been found in one stomach, 18 May beetles in another, and 13 cutworms in another. During the warmer parts of the year it is exceptional to find a stomach not well filled with insect remains. Meadow mice, white-footed mice, and house mice are the mammals most often taken, while chipmunks, wood rats, flying squirrels, and moles are less frequently found. The screech owl is fond of fish and catches many, especially in winter, when he watches near the breathing holes in the ice, and seizes the luckless fish which comes to the surface. Most of the birds destroyed by this owl are killed either in severe winter weather or during the breeding season, when it has hard work to feed its young. As nearly three-fourths of the owl's food consists of injurious mammals and insects, and only about one-seventh of birds (a large proportion of which are destructive English sparrows), there is no question that this little owl should be carefully protected.[1]

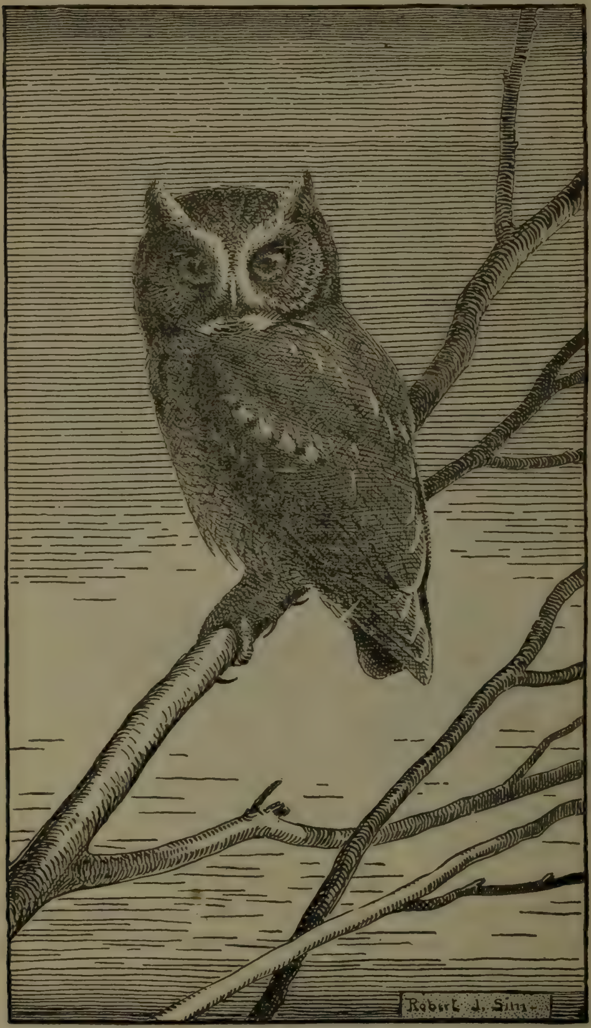


FIG. 14.—Screech owl.

W. L. M.

---

[1] Circ. 61, Biological Survey, pp. 12–13, 1907.

○

Issued May 6, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

Revised edition precedes

FARMERS' BULLETIN 497.

SOME COMMON GAME, AQUATIC, AND RAPACIOUS BIRDS IN RELATION TO MAN.

BY

W. L. McATEE and F. E. L. BEAL,
Assistants, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., March 18, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a report on Some Common Game, Aquatic, and Rapacious Birds in Relation to Man, by W. L. McAtee and F. E. L. Beal, assistants in the Biological Survey. Careful study of the food habits of the game birds, including the group known as shore birds, shows that these birds are of great value to the farmer. The water birds, as the grebes, gulls, and terns, have greater economic value and do less harm than is ordinarily supposed, while some species, like Franklin's gull and the black tern, are markedly beneficial. It is pointed out in this bulletin that many birds of prey are exceedingly valuable to the farmer, but the opposite is true of the Cooper's hawk, the sharp-shinned hawk, and the goshawk, which should be destroyed as the determined foes of poultry, game birds, and most of the smaller insectivorous species.

Respectfully,

Henry W. Henshaw,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
Prairie chicken (*Tympanuchus americanus*) 5
California quail (*Lophortyx californica*) 7
Ruffed grouse (*Bonasa umbellus*) 12
Introduced pheasants (*Phasianus torquatus* and *P. colchicus*) 13
Upland plover (*Bartramia longicauda*) 14
Killdeer (*Oxyechus vociferus*) 16
Horned grebe (*Colymbus auritus*) 18
Franklin's gull (*Larus franklini*) 19
Terns (*Sterna maxima*, *S. forsteri*, *S. hirundo*, *S. antillarum*, and *Hydrochelidon nigra surinamensis*) 22
Cooper's hawk (*Accipiter cooperi*) 26
Rough-legged hawk (*Archibuteo lagopus sancti-johannis*) 27
Sparrow hawk (*Falco sparverius*) 28
Long-eared owl (*Asio wilsonianus*) 29
Screech owl (*Otus asio*) 29

ILLUSTRATIONS.

Page.
Fig. 1. Prairie chicken 6
2. California quail 8
3. Ruffed grouse 12
4. Ringneck pheasant 13
5. Upland plover 15
6. Killdeer 17
7. Horned grebe 19
8. Franklin's gull 20
9. Common tern 23
10. Black tern 25
11. Cooper's hawk 26
12. Rough-legged hawk 27
13. Sparrow hawk 28
14. Screech owl 30

SOME COMMON GAME, AQUATIC, AND RAPACIOUS BIRDS IN RELATION TO MAN.

INTRODUCTION.

Game and aquatic birds, as a rule, have less economic interest than the species more closely associated with man. Nevertheless nearly all aquatic birds have important relations with the fishing industry. One of the birds, the horned grebe, sometimes accused of living entirely upon fish, is here shown to feed largely on crawfish, other crustaceans, and insects. Terns also have been held responsible for the serious reduction of food fishes in some localities, but a careful study of their food habits demonstrates that only a small proportion of their diet consists of such fishes. On account of the relatively small number of terns it is manifestly impossible for them to do all the damage attributed to them even if they fed exclusively on food fishes. Certain aquatic birds approach the land birds in feeding habits; examples are Franklin's gull and the black tern, both of which by their destruction of insects are beneficial to man All the shore birds are strikingly beneficial in their food habits, and the slaughter of these game birds deprives the farmer of valuable allies against some of the worst crop pests. The food habits of the upland plover and killdeer are here described as illustrating the beneficial qualities of the group. The gallinaceous game birds, as quail, grouse, and pheasants, take far less insect food than the shore birds, yet all of them do a certain amount of good. Because of their close contact with crops it is important that their economic relations be made widely known.

The hawks and owls have a bad name, but for the most part it is undeserved, and indiscriminate persecution of these birds is a serious mistake. Accounts of six species are given in this bulletin in order to point out the distinction between injurious hawks and owls and useful ones. The latter should be carefully protected.

PRAIRIE CHICKEN.

(*Tympanuchus americanus.*)

The prairie chicken (fig. 1), now common only in Kansas, Nebraska, Minnesota, the Dakotas, and Manitoba, is one of the birds which formerly occurred over a much wider range than at present and in

---

NOTE.—A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.

far greater abundance. It has been reduced principally by hunters, as have so many of our finest species of birds. Many sportsmen declare allegiance to the highest principles of game preservation yet fail to practice these principles. Our present game laws, even though efficiently administered, will save no species of birds, as the rapid growth of the army of sportsmen and pot hunters more than counterbalances the effect of the shortening of open seasons and reduction of bag limits. Moreover, game laws, as a general rule, are not strictly obeyed. In southern Wisconsin, where there was a closed season on prairie chickens for a term of years, to the writers' knowledge these birds were killed at every opportunity. The customary excuse was: "They are so scarce they won't breed up again anyway." Aside from showing culpable willingness to assist in the birds' extermination, this remark is untrue. Like all birds of its family the prairie chicken is very prolific, and if adequately protected would soon become numerous in its old haunts. The bird is easily domesticated, hence is eminently suited for propagation on preserves. As the increase of game in this manner is the only way to preserve it indefinitely and at the same time allow hunting, the plan

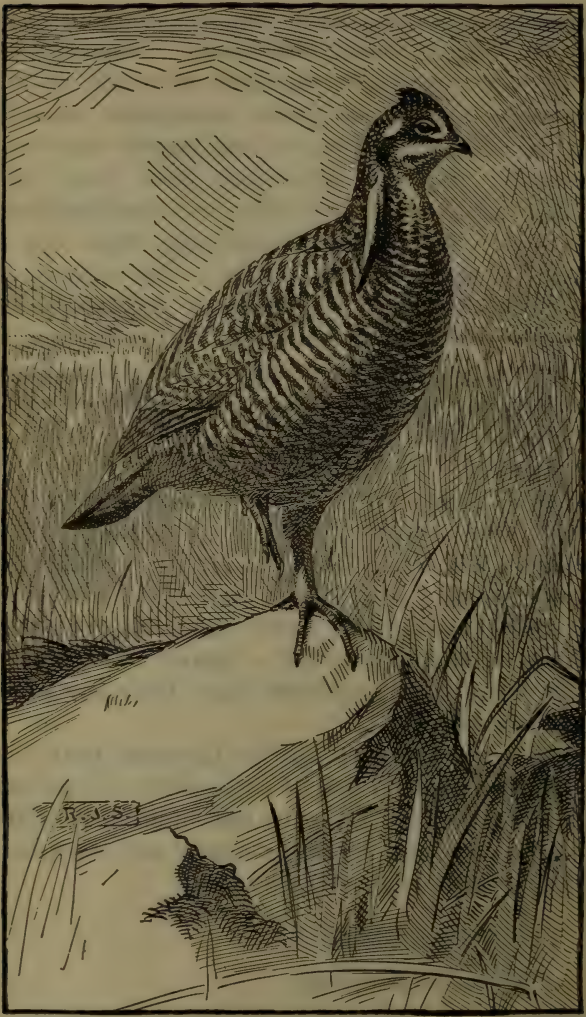


FIG. 1.—Prairie chicken.

should be actively put into operation by those most interested in the preservation of game—the sportsmen.

The prairie chicken is valuable not only as game, but as an efficient destroyer of farm pests, and any farmer would profit by having these birds reared on his place. Almost 15 per cent of the bird's food consists of weed seeds, including those of such pests as foxtail grass, smartweeds, and ragweed. More than 10 per cent of the diet consists of rose hips. A few other fruits are eaten and more than a fourth of the food consists of leaves, flowers, and shoots, collectively known as browse. The prairie chicken eats a great deal of grain, but takes most of it from stubble. The bird is fond of such mast as hazelnuts and acorns.

Nearly 15 per cent of the bird's food consists of insects, the bulk of them being grasshoppers. Almost every kind of grasshopper, locust, or cricket appears to be acceptable, and nearly 20 different kinds were identified from the stomachs. The prairie chicken made itself especially useful during the destructive invasions of the Rocky Mountain locust. Sixteen birds examined at that time were found to have eaten 866 locusts. Among other pests eaten by this species are the Colorado potato beetle, 12-spotted cucumber beetle, sugar-beet leaf-beetle, May beetles, cotton worm, army worm, cutworms, the yellow bear caterpillar, and chinch bug.—W. L. M.

CALIFORNIA QUAIL.

(*Lophortyx californica.*)

The California quail (fig. 2) is common and generally distributed over the States west of the Sierra, except at the higher altitudes, and is especially abundant in the fruit-raising sections. Like the bob-white of the East, this quail never goes far from cover, and it delights to dwell on unimproved land where trees and chaparral alternate with small areas of open ground. In settled regions it is somewhat domestic in habits and soon becomes accustomed to living in orchards, gardens, and cultivated grounds. The writer has seen a female sitting upon her eggs in a garden within 30 feet of a house, between which and the nest carriages and foot passengers passed many times each day. In winter a covey frequently feeds with the farmer's chickens, and if not disturbed will continue to do so until pairing time.

The natural food of the quail consists of the seeds of the vast number of plants known as weeds, with a little foliage of the same, especially in winter, when the leaves are young and tender. Considering how small is the amount of fruit usually found in the stomach of this bird, it is a surprise to learn that it sometimes does serious damage to vineyards. Investigation, however, shows that, as in most other similar cases, the injury results only when too many birds gather in a limited area. Nearly all the complaints against the quail for eating fruit are that it visits vineyards in immense numbers and eats grapes. When thousands visit a vineyard, even if only occasionally, and each bird eats or spoils at least one grape, the result is disastrous.

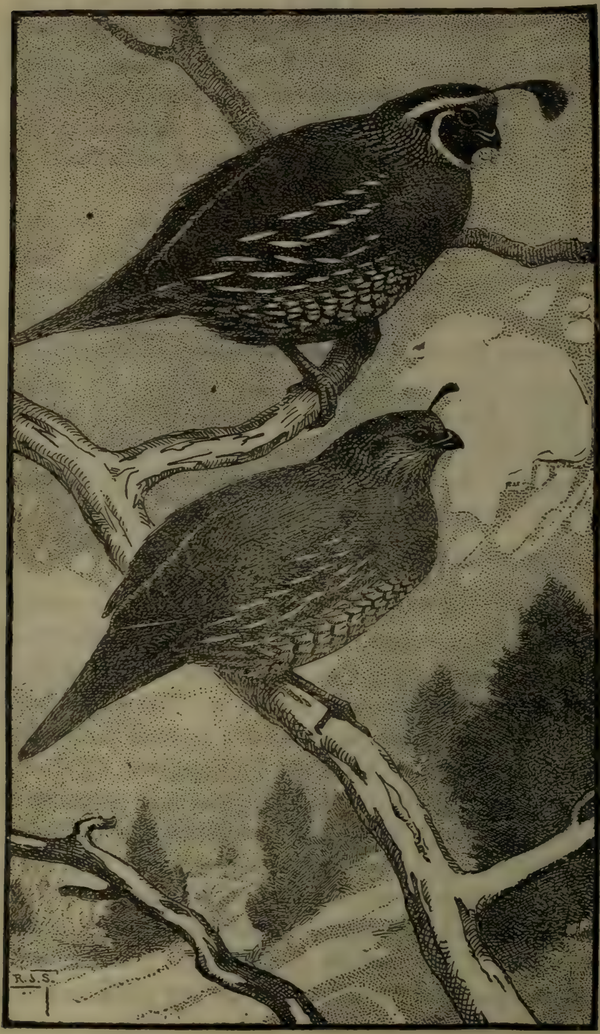


FIG. 2.—California quail.

An observer states that he once saw a flock of about 1,000 quail eating Zinfandel grapes in a vineyard in the central part of the State, and another says that in southern California he has seen as many as 5,000 feeding upon Muscat grapes. In the writer's interviews with California fruit growers, only one mentioned the quail as harmful. His ranch was situated along the hills on the side of a narrow valley, adjacent to wild grazing land with much chaparral and forest, among which the quail lived. In this case the annual loss was estimated at 2 or 3 tons of grapes.

In the laboratory investigation of the food of the California quail 619 stomachs were examined. They were collected in every month except May, but only one was obtained in March. The other months are well represented. Animal food, principally insects, amounts to but 3 per cent, and most of this was found in the stomachs of young birds, mere broodlings. Vegetable food amounts to 97 per cent and consists mainly of seeds of plants most of which are of noxious or troublesome species.

Animal food.—Ants appear to be a favorite food. They were found in 82 stomachs, and were eaten by adults as well as by young. They amount, however, to less than 1 per cent of the whole diet. The rest of the animal food aggregates a little more than 2 per cent and is distributed as follows: Beetles in 30 stomachs, bugs (Hemiptera) in 38, caterpillars in 11, grasshoppers in 7, flies in 2, spiders in 6, millepeds in 1, and snails in 2. The most interesting point in this connection was the stomach of a broodling only 3 or 4 days old. Besides several adult Hemiptera, some ants, caterpillars, and spiders, and a few seeds, it contained 280 minute insects, which constituted 76 per cent of the stomach's contents, and were identified as an immature form of species of scale, *Phenacoccus helianthi.*

In this connection the following extract from a letter dated at Los Angeles, Cal., October 28, 1908, by Dr. W. G. Chambers to the Secretary of Agriculture, is interesting:

> Last May during the hatching season one of my female quail died a week prior to completing the hatch. An incandescent light of 8 candlepower was substituted, the result being 15 baby quail, very wild at first, not understanding human sounds or language, but finally becoming as docile as pet chickens. They were raised in my back yard, running at large after the first week.
>
> A number of Marguerite bushes which grow in profusion in the yard were so infested with black scale that I had decided to uproot them and had postponed doing so as the little quail worked so persistently among the branches; upon investigation I discovered them eating the scale and twittering happily; they would swallow the fully developed scale and thoroughly clean the branches of all those undeveloped.

The young in the first week of life eat animal matter to the extent of from 50 to 75 per cent of the food, but by the time they are 4 weeks old they take little if any more animal food than the adults.

Vegetable food.—The vegetable part of the quail's food may be divided into fruit, grain, seeds, and forage. Fruit appeared in 106 stomachs and aggregates 2.3 per cent of the yearly diet. It was distributed as follows: Grapes in 7 stomachs, prunes in 9, apples in 3, rubus (blackberry or raspberry) in 4, olive in 1, elderberry in 21, snowberry in 8, Manzanita in 2, huckleberry in 11, and rose haws in 3. Pulp and skins, identified as fruit only, were found in 27 stomachs, and unknown seeds, probably those of some small fruit or berry, occurred in 10 stomachs. It is evident that the percentage of any one of the above is insignificant. Stomach examination throws no new light upon the quail's grape-eating habits, except to show that the ravages complained of are exceptional. That fruit does not constitute any important part of the bird's annual food is clearly proved.

Grain was found in 133 stomachs and constitutes 6.4 per cent of the food. It was distributed as follows: Corn in 14 stomachs, wheat in 15, oats in 13, barley in 89, and rye in 2. The principal complaints against the quail on the score of grain eating are that flocks sometimes visit newly sown fields and eat large quantities of the seed. Walter E. Bryant says on this point:

> Two males which I shot one evening as they were going to roost for the night after having been feeding on a newly sown field contained the following, mainly in the crop: (*a*) Two hundred and ten whole grains of barley, 6 pieces of broken barley, 3 grains of "cheat," and 1 of wheat, besides a few barley hulls, some clover leaves, and alfilaria; (*b*) 185 whole grains of barley, 5 broken pieces, 4 grains of "cheat," and 2 of wheat; also barley hulls, clover, and alfilaria. The flock numbered nearly or quite 20 birds.[1]

Only one report accuses the bird of eating grain from the harvest field. Mr. W. T. Craig, of San Francisco, writing to the United States Department of Agriculture, says:

> I have observed the quail enter a field of wheat to the number of thousands, and had they not been driven away they would have destroyed the whole crop.

Stomach examination does not indicate any month in which grain is eaten in excess of other food. January shows the highest percentage, 12.4, but November is nearly as high, while December, although between the two, shows less than 3 per cent. A little more than 3 per cent was eaten in February, and none at all in March and April, though the newly sown grain would be accessible in one at least of these months. June and July, the harvest months, show, respectively, 4.1 per cent and 10.7 per cent. In fact the stomach record plainly indicates that the quail does not make special search for grain, but being naturally a seed eater takes grain when it comes in the way.

The seeds of a multitude of plants which have no apparent useful function except to increase by their decay the deposit of humus in the soil constitute the staff of life of the quail. In this particular investigation they aggregate 62.5 per cent of the food of the year. They appear in stomachs taken in every month and reach a good percentage in each, the only months that show much diminution in quantity being January, February, March, and April, when new forage partly replaces seeds. The percentage is highest in June, 85.9, but shows no great falling off from July to December, inclusive. Seventy-three kinds of seeds were identified, at least generically, and more than half of them were determined specifically. Many more were ground up so as to be unrecognizable.

Bur thistle, lupines, bur clover, and turkey mullein appear to be the favorite seeds; that the others are not distasteful is shown by the quantities found in some stomachs. For instance, mayweed was identified in only 27 stomachs, yet one stomach contained at least 2,000 of these seeds; pigweed (*Chenopodium*) in but 11, yet 1 contained 1,000. One stomach held 83 kernels of barley, 592 seeds of geranium, 560 of tarweed, 40 of bur thistle, 48 of clover, 80 of alfilaria, 704 of timothy, 32 of catchfly, and 5 of snowberry, or 2,144 seeds in all. Another contained 1,696 geranium seeds, 14 bur thistle, 24 knotweed, 14 tarweed, 38 bur clover, 148 alfilaria, 12 ray grass, and 1 unknown seed, and a pod of uncertain origin—in all, 1,947 seeds and a pod. In both cases the contents of the crop is included with that of the stomach or gizzard. These samples indicate considerable variety in the quail's diet, even in one meal.

---

[1] Zoe, IV, pp. 55–56, 1893–94.

Grass and other forage constitute a little over 25 per cent of the quail's annual food. Forage amounts to less than 1 per cent in June, remains about the same until October, and increases somewhat in November. In January it becomes important, and it reaches nearly 60 per cent of the food for the next four months. The maximum, 85 per cent, occurs in March; but this percentage, based on only one stomach, can not be considered final. Seeds and forage are practically complementary to each other; that is, as one increases the other decreases. June, which shows the least forage, has the largest percentage of seeds. Leaves of red and of bur clover and of alfilaria were the favorite kinds, and in some cases constituted the whole stomach contents. Blades of grass are frequently taken. A few bits of acorn, and perhaps other nuts, were eaten, but the quantity is insignificant.

Summary.—From the above analysis of the food of the California quail it is apparent that under normal conditions the farmer and fruit grower have nothing to fear from its ravages. When, however, large areas of chaparral land are cleared and brought under cultivation, it is natural that the products of garden and vineyard should be eaten to a greater or less extent by quail, which abound in such localities. On the other hand, its seed-eating record is in its favor. Usually there is little difficulty in getting rid of a superfluity of game birds; in fact, in most cases the trouble is to prevent their extermination. This is strikingly illustrated by the fact that, in order to restock its depleted covers, an attempt is now being made in southern California to import quail from the peninsula of Lower California. A bird so large, so easily trapped, so valuable for food, and withal one whose pursuit affords such excellent sport as the valley quail, will rarely become numerous enough to do serious damage, and then only locally and under unusual conditions. When such conditions arise, a reduction of numbers is the easiest and simplest cure. Permits to trap quail on one's own premises are obtainable in California on application to the State fish commissioner. After the birds have been sufficiently reduced they can be kept within reasonable limits by a moderate amount of shooting in the proper season.—F. E. L. B.

RUFFED GROUSE.

(*Bonasa umbellus.*)

The ruffed grouse (fig. 3), called "partridge" in the northeastern States and pheasant in some other parts of its range, is one of our most widely ranging game birds. It inhabits wooded regions from Canada and Alaska south to California, Colorado, Tennessee, and northern Georgia. It is usually a wild and wary bird and well withstands the attacks of hunters, but it responds to protection in a gratifying manner and has proved to be well adapted to propagation under artificial conditions. On account of these qualities and its desirability as a game species it is a good subject for game farming.

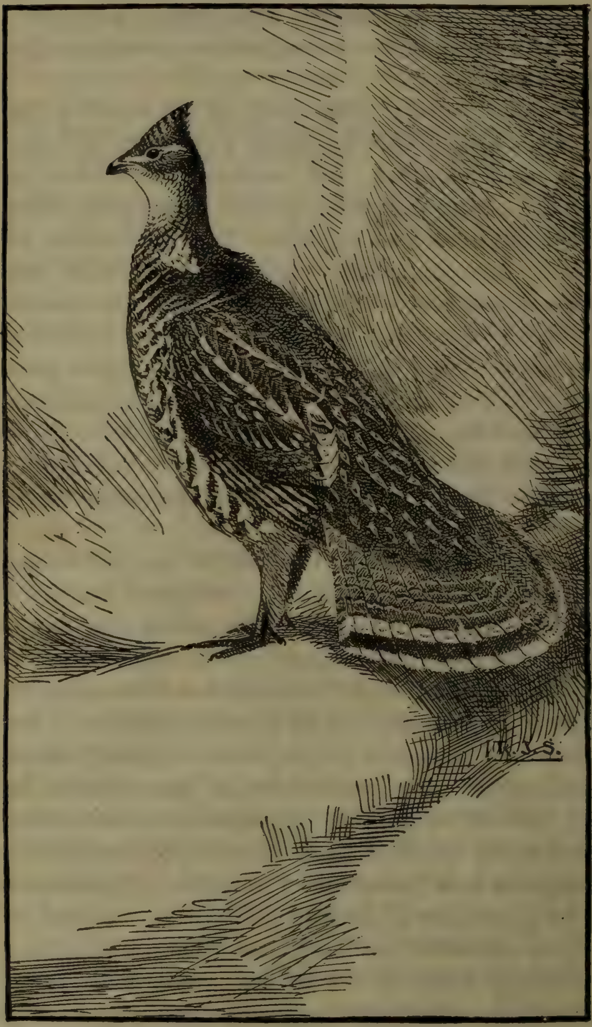


FIG. 3.—Ruffed grouse.

Wild fruits, mast, and browse make up the bulk of the vegetable food of this species. It is very fond of hazelnuts, beechnuts, chestnuts, and acorns and it eats practically all kinds of wild berries and other fruits. Nearly 60 kinds of fruits have been identified from the stomach contents examined. Various weed seeds are also consumed.

Slightly more than 10 per cent of the food consists of insects, about half of which are beetles. The most important pests devoured are the Colorado potato beetle, clover-root weevil, the pale-striped flea beetle, grapevine leaf-beetle, May beetles, grasshoppers, cotton worms, army worms, cutworms, the red-humped apple caterpillar, and sawfly larvæ.—W. L. M.

INTRODUCED PHEASANTS.

(*Phasianus torquatus and P. colchicus.*)

While introduced pheasants may hardly seem to deserve a place on a list of common birds, the extent to which they are being imported and propagated in the United States makes it desirable that information be made available as to their feeding habits when liberated. Ringneck pheasants (fig. 4) have long been established in Oregon, Washington, and British Columbia, and are less common in the wild state in Massachusetts, New York, Indiana, and Kansas. But persistent efforts, in some cases on a very large scale, are being made to establish pheasants in other States, and the farmers whose land they are likely to range over should have access to information concerning their economic value.

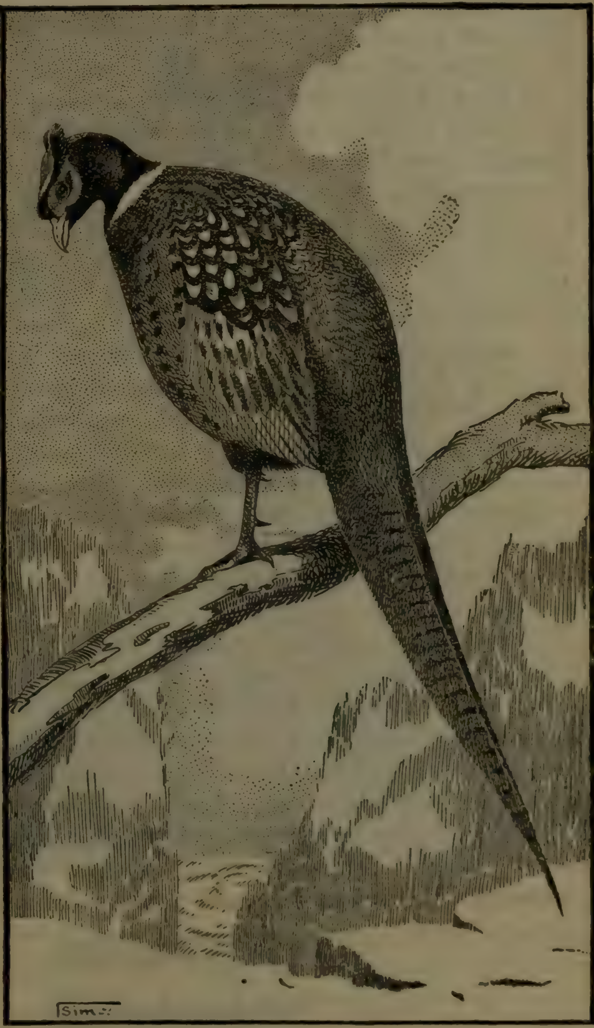


FIG. 4.—Ringneck pheasant.

Severe criticism of pheasants and fulsome praise are about equal in volume. The birds are accused of digging newly planted and sprouting corn, oats, barley, and beans, and seeds of melons, cucumbers, and squashes. It is claimed that because of their depredations it has been necessary to replant whole fields of corn. They are said to drive chickens away from their food and even to kill young poultry. Some landowners in Ontario County, N. Y., claim that the loss suffered on account of pheasants has been more than twice the amount of their taxes.

On the other hand the birds have not proved a nuisance in Oregon and Washington, where they have been numerous for years. Some farmers even value them so highly that they will not permit hunting on their property.

The few pheasant stomachs examined indicate that these birds are very fond of grain. Oats and wheat compose about 34 per cent of the food of 12 ringneck pheasants collected in Oregon and Washington, and 82.5 per cent of the stomach contents of two English pheasants from British Columbia. But all of these birds were taken in September, October, and December; hence it is probable that all of this grain was waste. The next largest item of food in these stomachs was insects, consisting entirely of larvæ of March flies (*Bibio*). One stomach contained no fewer than 360 of these larvæ and another 432. The remainder of the food included acorns, pine seeds, browse, peas, rose hips, snowberries, and seeds of dandelion, lupine, bur clover, black mustard, and chickweed.

From 200 to 960 kernels of wheat and oats were taken by various birds; about 200 peas were found in one stomach, but it was evident that these were the old and partly decomposed refuse of the harvest. Twenty-three acorns and 200 pine seeds were taken by the bird which ate the largest amount of mast, and about 800 capsules of chickweed, containing more than 8,000 seeds, were in the stomach of the best weed-seed eater.

What is most evident is that pheasants are gross feeders; their capabilities for good or harm are great. If a number of them attack a crop they are likely to make short work of it, or if they devote themselves to weed seeds or insect pests they do a great deal of good. It seems therefore that the question of the economic value of pheasants is peculiarly a local one. Much depends on the proportion of land under cultivation, the kind of crops raised, and the quantity of wild food available. Apparently the chances are about even that imported pheasants will or will not become useful economic factors.—W. L. M.

UPLAND PLOVER.

(*Bartramia longicauda.*)

The upland plover (fig. 5) forms a striking exception in habits to its closest relatives, the sandpipers. While sandpipers love the vicinity of water, the upland plover frequents dry hills and prairies and is most abundant in the interior. This so-called plover breeds from Oregon, Oklahoma, and Virginia north to Alaska, Mackenzie, and Maine, and migrates over the more southern parts of the continent, passing to the pampas of Argentina to spend the winters.

From its habits the upland plover would naturally be expected to have a closer relation to agriculture than most sandpipers, and such proves to be the case. Almost half its food is made up of grasshoppers, crickets, and weevils, all of which exact heavy toll from cultivated crops. Among the weevils eaten are the cottonboll weevil; greater and lesser clover-leaf weevils; clover-root weevil; *Epicærus imbricatus*, which is known to attack almost all garden and orchard crops; cowpea curculios; *Tanymecus confertus*, an enemy of sugar beets; *Thecesternus humeralis*, which has been known to injure grapevines; and bill bugs. *Thecesternus* alone composes 3.65 per cent of the seasonal food of the 163 stomachs examined, and bill bugs constitute 5.83 per cent. No fewer than 8 species of bill bugs were identified from the stomachs. These weevils injure, often seriously, such crops as corn, wheat, barley, and rye, as well as forage plants of many kinds.

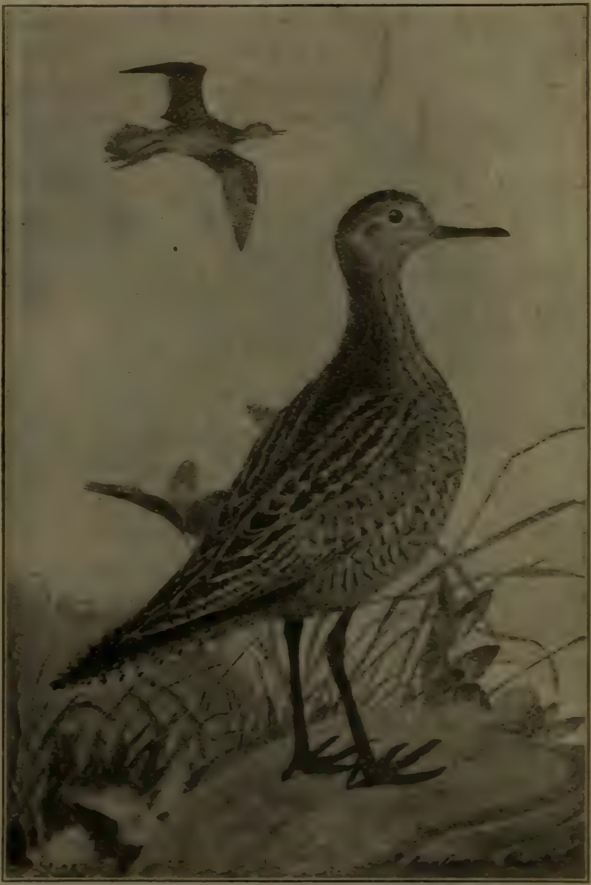


FIG. 5.—Upland plover.

The upland plover further makes itself useful to the farmer by devouring leaf-beetles, including the grapevine colaspis, southern corn leaf-beetle, and other injurious species; wireworms and their adult forms, the click beetles; white grubs and their parents, the May beetles; cutworms, army worms; cotton worms; cotton cutworms, sawfly larvæ; and leatherjackets or cranefly larvæ. They befriend cattle by eating horseflies and their larvæ, and cattle ticks.

They eat a variety of other animal forms, such as moths, ants, and other Hymenoptera, flies, bugs, centipeds and millepeds, spiders, snails, and earthworms. Practically 97 per cent of the food consists of animal matter, chiefly of injurious and neutral forms. The vegetable food comprises the seeds of such weed pests as buttonweed, foxtail grass, and sand spurs, and hence is also to the credit of the bird.

Notwithstanding that the upland plover injures no crop and consumes a host of the worst enemies of agriculture, it is one of the numerous shore birds that have been hunted to the verge of extinction. Can it be that the American public will allow one of the best friends of agriculture to be exterminated by hunters who care only for the momentary excitement of dropping these swiftly flying birds and the pleasure of devouring the few mouthfuls of savory flesh they afford?—W. L. M.

KILLDEER.

(*Oxyechus vociferus.*)

The killdeer (fig. 6) is one of the best known American birds. It frequents cultivated lands and even roads and the vicinity of buildings. It is well named "vociferus," for it delights in repeating the loud and penetrating call of "kill-dee, kill-dee," from which its common name is taken. The killdeer nests throughout the United States and southern Canada. Some individuals spend the winter in the southern half of the United States or occasionally even farther north, while others go as far south as northern South America.

Like the upland plover the killdeer spends much of its time away from water. It frequently nests in cornfields or pastures and, as noted above, even comes about the abode of man. These preferences naturally influence the food habits of the species, affording it an opportunity to destroy insects which are directly related to agriculture. The food of the killdeer is varied, being composed of the following principal items: Beetles, 37.06 per cent; other insects, as grasshoppers, caterpillars, ants, bugs, caddis flies, dragon flies, and two-winged flies, 39.54 per cent; and other invertebrates, as centipeds, spiders, ticks, oyster worms, earthworms, snails, crabs, and other crustacea, 21.12 per cent. Vegetable matter composes 2.28 per cent of the total food, and is chiefly made up of weed seeds, such as buttonweed, smartweed, foxtail grass, and nightshade.

Among the injurious beetles consumed are the following weevils: Alfalfa weevil, cotton-boll weevil, clover-root weevil, clover-leaf weevil, rice weevil, cowpea curculio, white-pine weevil, and bill bugs. The latter alone constitute more than 2 per cent of the whole food. The alfalfa weevil, a new and destructive pest, is relished by the killdeer, 41 being found in a single stomach. Other destructive beetles devoured are white grubs and their adult forms, the May beetles; wireworms and their imagos, the click beetles; larvæ of the genus *Ligyrus*, which attack sugar cane, corn, and carrots; brown-fruit beetles, which injure apples and corn; the grapevine leaf-beetle; southern corn-leaf beetle; two-striped tortoise beetle, which injures sweet potatoes; and a flea beetle which attacks tobacco and sugar beets.

Cicadas, buffalo tree hoppers, and negro bugs, the last named injuring parsley and raspberries, are some of the true bugs relished by the killdeer. Caterpillars are a favorite article of diet, and several very injurious species are eaten, as the cotton worm, cotton cutworm, other cutworms, and caterpillars of the genus *Phlegethontius*, which damage tomatoes and tobacco. Grasshoppers and crickets, including mole crickets, are a staple food. Two-winged flies or Diptera furnish 11.91 per cent of the food of the killdeer. Such pests as crane flies and their larvæ, known as leatherjackets, are eaten, as well as horse-flies and mosquitoes and their larvæ. One stomach contained hundreds of larvæ of the salt marsh mosquito (*Aëdes sollicitans*), which is one of the most troublesome of the biting species. The State of

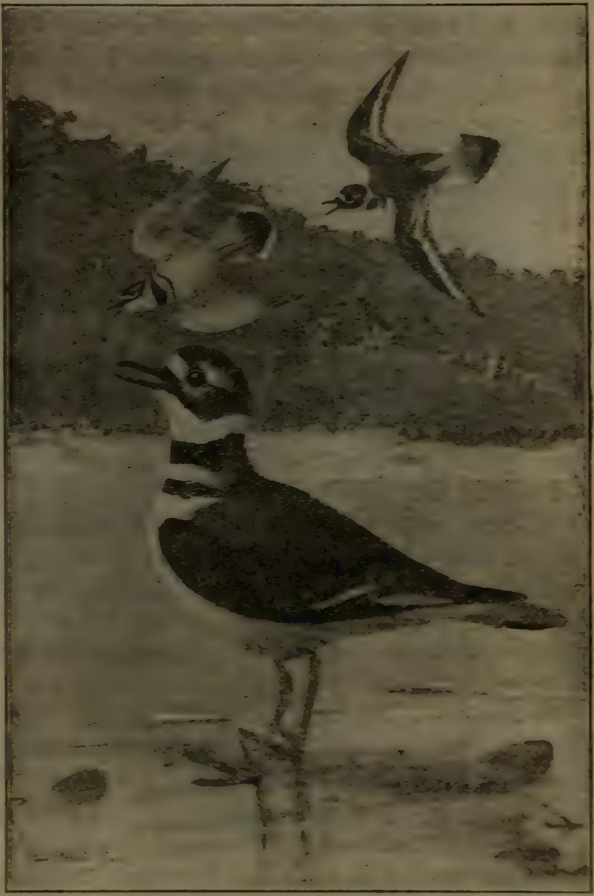


FIG. 6.—Killdeer.

New Jersey has spent thousands of dollars in trying to reduce the numbers of this pest. The killdeer thus befriends man, but it does something also for the domestic animals, not only by eating horseflies and mosquitoes, as just mentioned, but also by preying upon ticks, including the American fever or cattle tick, which has caused such enormous losses in some parts of the South.

Crawfish, well-known pests in levees, and even in corn, cotton, and other fields in certain localities, are another item of the killdeer's food, and 3.62 per cent of the subsistence of the 228 birds examined was composed of worms of the genus *Nereis*, which prey upon oysters.

In all, 97.72 per cent of the killdeer's food is composed of insects and other animal matter. The bird preys upon many of the worst crop pests and is a valuable economic factor. There can be no logical reason for continuing to regard it as a game bird.—W. L. M.

HORNED GREBE.

(*Colymbus auritus.*)

Grebes are among the most interesting of water birds. Their power of diving as quick as a flash or of sinking beneath the surface without leaving a ripple has earned for them such names as hell-diver, sprite, and water witch. Grebes are not only accomplished divers, but swim well under water for long distances—not exclusively by aid of the feet, however, as is often stated. The writer has more than once seen the pied-bill grebe using its wings in underwater progression. Grebes have difficulty in rising from the water, but fly well when under way. When alighting they strike the water with a splash, gliding some distance on the breast. The nests are built of water-soaked vegetation, a portion of which is used to cover the eggs in the absence of the parents.

To illustrate the food habits of grebes, the horned grebe (fig. 7) is chosen. This species has a circumpolar range. In North America it breeds from the northern tier of the United States northward, and winters from the southern boundary of the breeding range south to Florida and California. The most remarkable point about the food habits of grebes is that the stomachs almost invariably contain a considerable mass of feathers. Feathers are fed to the young, and there is no question that they play some essential though unknown part in the digestive economy. As they are finely ground in the gizzards it is probable that finally they are digested and the available nutriment assimilated. Feathers constituted practically 66 per cent of the contents of the 57 horned grebe stomachs examined. However, it is not likely that they furnish a very large percentage of the nourishment needed by the birds. As the nutritive value of the feathers is unknown, this part of the stomach contents is ignored.

The other items of food are assigned 100 per cent, and the percentages are given on that basis. Various beetles, chiefly aquatic, compose 23.3 per cent of the food; other insects (including aquatic bugs, caddis and chironomid larvæ, dragon-fly nymphs, etc.), nearly 12 per cent; fishes, 27.8 per cent; crawfish, 20.7 per cent; and other crustacea, 13.8 per cent. A little other animal matter is taken, including snails and spiders, and a small quantity of vegetable food was found in two stomachs.

It has been claimed that grebes live exclusively on fishes and do mischief in fish hatcheries. The results obtained by stomach examinations show that they do not depend wholly or even chiefly upon fish. On the contrary, they eat a large number of crawfishes, which often severely damage crops, and consume numbers of aquatic insects which devour small fishes and the food of such fishes.—W. L. M.

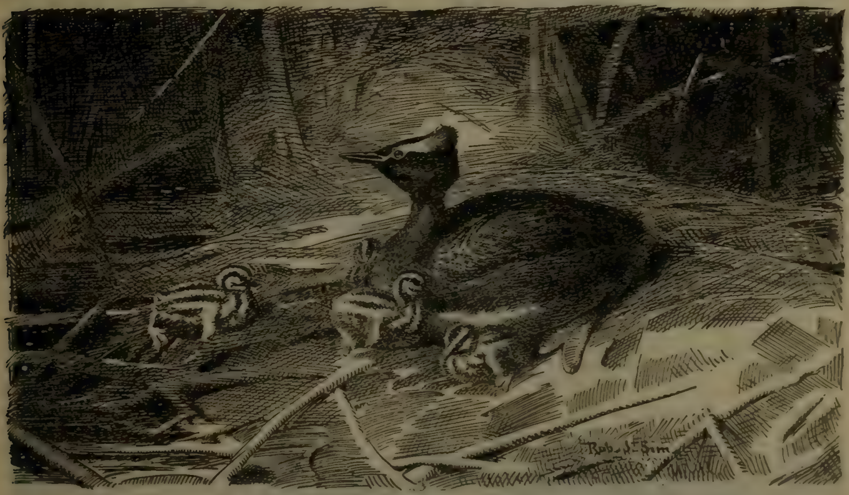


FIG. 7.—Horned grebe.

FRANKLIN'S GULL.

(*Larus franklini.*)

The term "gull" usually suggests a vision of dashing spray or far-extending beaches with reedy bays and outreaching points of sand or islets on which the birds rest to preen their feathers after their long flights, and where perchance they make their nests and rear their young. The species under consideration (fig. 8), however, spends little time on the seacoast but is an inhabitant of far-inland prairies and broad reaches of marsh land, where it lives and breeds during the warm season. In winter it retires southward, but lingers long enough in some of the Southern States to be of material assistance to agriculture. Its center of abundance in North America during the breeding season is west of the Mississippi River and north of Iowa, east of the Rocky Mountains, but it is known to breed to some extent both south and east of these limits. The marshy lakes of this region afford ideal nesting sites for the species, while the adjoining broad stretches of prairie land yield an abundance of their favorite food. A few decades ago these birds occupied this vast region undisturbed, but to-day the plow is turning up the sod and the mower cutting the grass of the boundless fields over which for centuries they have foraged. With the advent of agricultural operations some changes harmful to the birds must necessarily take place, but it behooves the tillers of the soil to leave the gulls unmolested as far as possible, for where they abound they are a most potent factor in the reduction of insect life. They do not by any means confine themselves to marshes when seeking for food, but fly over the dry prairie and even visit cultivated fields, looking for grubs, grasshoppers, and other insects. When unmolested they become quite fearless and follow the plowman to gather the grubs and worms from the newly turned furrows.

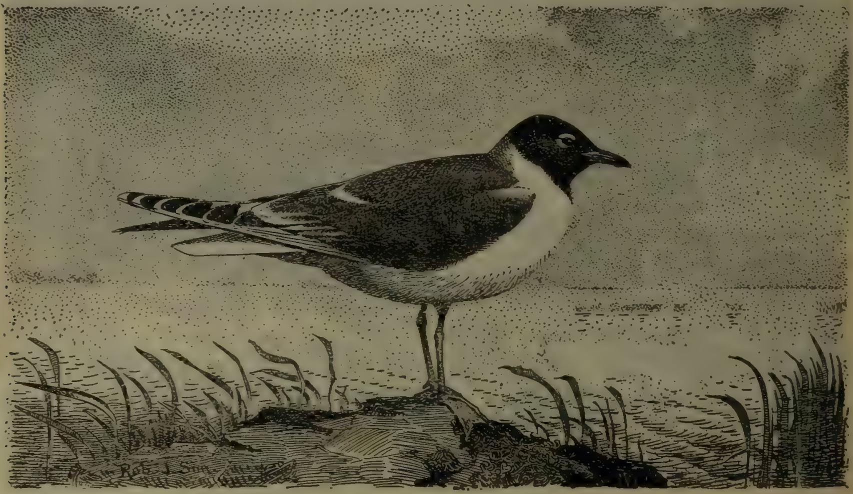


FIG. 8.—Franklin's gull.

In an investigation of the food of Franklin's gull 93 stomachs were examined. Nearly all were taken from their breeding grounds and in the breeding season. Unfortunately none were secured during July, which is probably the very height of the reproductive period.

Of the whole food 94.46 per cent consisted of animal matter and 5.54 per cent of vegetable. Of the latter nearly all was of no significance, probably being taken accidentally, except the contents of

2 stomachs collected in May in North Dakota. About 75 per cent of the contents of each of these consisted of wheat probably gathered from newly sown fields. This was the only vegetable food found in any stomach that was of the least economic value.

Of the animal food the most important item is grasshoppers. These amount to 43.43 per cent of the food of the season, and in September and October constitute over four-fifths of the whole diet. As an example of the number these birds can eat at a single meal, the following may be cited. Stomach A contained 70 entire grasshoppers and jaws of 56 more, with remains of 3 crickets. Stomach B contained 20 beetles, 66 crickets, 34 grasshoppers, and 3 other insects. Stomach C contained 90 whole grasshoppers, the jaws of 52 more, with 8 crickets, 1 bug, and 1 caterpillar. Stomach D contained 82 beetles, 87 bugs, 984 ants, 1 cricket, 1 grasshopper, and 2 spiders, or 1,157 insects in all. Stomach E was filled with 327 nymphs of dragon flies. Several other stomachs were completely filled with grasshoppers and crickets, too far advanced in digestion to be counted. Adults and larvæ (grubs) of May beetles were also a large component of the food and these were probably taken upon cultivated ground. Stomachs collected in Louisiana during the fall migration contained in addition to grasshoppers and beetles large numbers of true bugs (Hemiptera), including several species which are injurious to cotton, tobacco, and squashes. From this brief statement of the food of Franklin's gull, farmers will readily perceive that these birds are very desirable neighbors and will do all in their power to protect them.

There are several other species of gulls and terns that, like Franklin's, take up their residence about the lakes and marshes in the interior of the country. Their food habits, as far as known, are all beneficial to the farmer. They are great eaters of grasshoppers and have been seen catching those insects on the wing and also may often be seen following the plow in search of the grubs and beetles turned up. Among these are the California gull (*Larus californicus*), the ring-billed gull (*Larus delawarensis*), and the black tern (*Hydrochelidon nigra surinamensis*). The latter lives and breeds about marshes where there is often little or no open water.

An illustration of the value of gulls as insect destroyers is furnished by the experience of the Mormons when they settled in Utah and raised their first crops of grain. This is graphically described by Hon. Geo. A. Cannon, temporary chairman of the Third Irrigation Congress:

> Black crickets came down by millions and destroyed our grain crops; promising fields of wheat in the morning were in the evening as smooth as a man's hand—devoured by the crickets. At this juncture sea gulls [California gulls] came by hundreds and thousands, and before the crops were entirely destroyed these gulls devoured the

insects, so that our fields were entirely freed from them. The settlers at Salt Lake regarded the advent of the birds as a heaven-sent miracle. * * * I have been along the ditches in the morning and have seen lumps of these crickets vomited up by these gulls, so that they could again begin killing.

These "lumps of crickets" were undoubtedly "pellets" of the indigestible parts habitually disgorged by the birds. At the time of the Nevada mouse plague in Humboldt Valley in 1907, gulls, as well as hawks and owls, were noted feasting on the destructive rodents.—F. E. L. B.

TERNS.

Like the gulls, terns are usually associated in the mind with the seacoast, but at least six species breed in the interior of the continent. The terns are expert in flight, and so trim and graceful in appearance that they have received the name sea swallows. They breed in colonies, usually nesting on low islands. This leads to the destruction of large numbers of eggs and young by high tides. Formerly terns were slaughtered for millinery purposes to such an extent that some species have been almost extirpated.

Persons engaged in the plumage business have made the not disinterested charge that terns devour large numbers of food fishes and hence should be destroyed. In order to ascertain the truth of the matter the Biological Survey has made a thorough examination of the question. Too few stomachs of the caspian, roseate, and arctic terns have been examined to form a basis for satisfactory conclusions, but a fair number of stomachs of five other species were available—the royal tern, Forster's tern, common tern, least tern, and black tern.

Royal tern (*Sterna maxima*).—Twenty-four stomachs were examined. They contained 3 per cent of crustacea and 97 per cent of fish. The fishes were yellow perch (*Perca flavescens*), 4 per cent, taken in North Carolina in July; bluefish (*Pomatomus saltatrix*), 8 per cent, taken in Florida in March; menhaden (*Brevoortia tyrannus*), 65 per cent, taken in Georgia in November and December, Alabama in October, and Florida in February, August, October, November, and December; and unidentified fishes, 20 per cent.

Thus it is probable that not more than 16 per cent of the normal food consists of fishes eaten by man. The feeding upon menhaden, tons of which are made into fertilizer, is insignificant economically.

Forster's tern (*Sterna forsteri*).—The food of 34 specimens of this species consisted of crustacea, 2 per cent, and fish, 98 per cent. The largest item of finny food was menhaden (*Brevoortia tyrannus*), 28.2 per cent, found in stomachs taken in South Carolina, Georgia, and Florida in November, December, and January, respectively. Silvery anchovies (*Stolephorus*) (not the anchovies of commerce), forming 24.1 per cent, were next in rank. They were taken in California in September and December, and in Georgia and Florida in November, December, and January. Fresh-water minnows (*Cyprinidae*) composed 20.5 per cent of the food. Following these in importance were pompanos (*Trachinotus carolinus*), 5.9 per cent; round herrings (*Etrumeus sadina*), 5.8 per cent; mummichogs (*Fundulus zebrinus*) and fresh-water sticklebacks (*Eucalia inconstans*), 2.6 per cent each. Unidentified fish made up 7.3 per cent of the food.

Thus only 5.9 per cent of the food of Forster's tern, as at present known, consists of food fishes; 92 per cent consists of fishes of no direct value to man, among which are sticklebacks, which feed upon the spawn of other fishes.

Common tern (*Sterna hirundo*).—One hundred and sixteen stomachs of the common tern (fig. 9) have been examined. One per cent of their food consists of mollusks, crustacea, and the worms (*Nereis*) which feed upon oysters. Two per cent is composed of moths and 1.5 per cent of other insects, including grasshoppers, crickets, ants, dragon flies, caddis flies, beetles, and bugs. The remaining 95.5 per cent consists of fishes. The largest

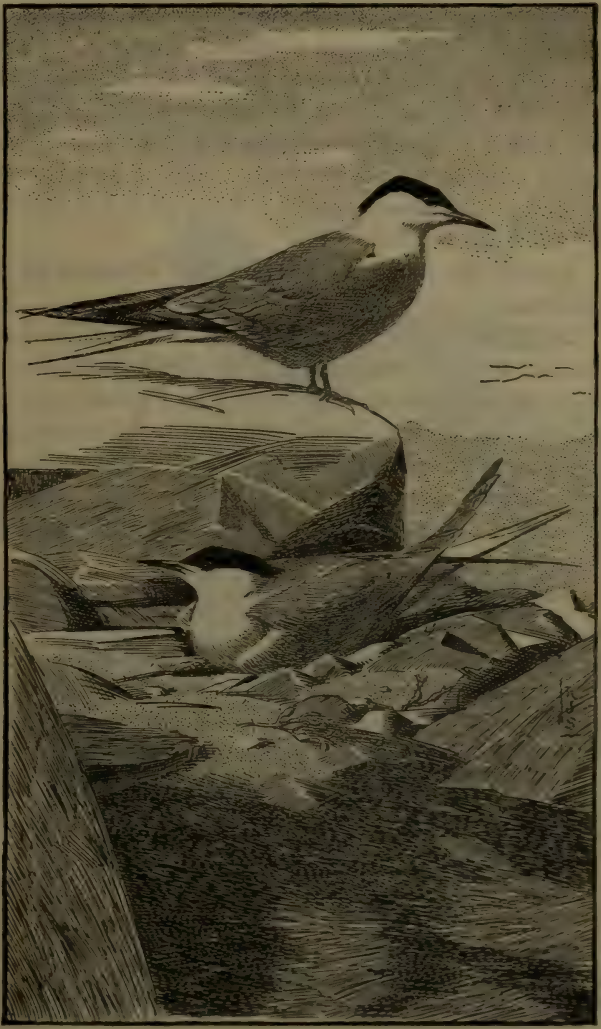


FIG. 9.—Common tern.

item is fresh-water minnows (*Cyprinidæ*), 23.3 per cent. Sand launces (*Ammodytes americanus*) make 17.8 per cent of the food. Other fishes eaten are menhaden (*Brevoortia tyrannus*), 5.1 per cent; yellow perch (*Perca flavescens*) and sticklebacks (*Gasterosteus bispinosus*), 4.3 per cent each; and silvery anchovies (*Stolephorus*), chub mackerel (*Scomber colias*), and silversides (*Menidia*), 1 per cent each.

Only 6 per cent of the bird's food is composed of food fishes. To offset this, 3.5 per cent consists of insects, mostly injurious, and 4.3 per cent of sticklebacks, of which a distinguished naturalist (Günther) says: "It is scarcely to be conceived what damage these little fishes do, and how greatly detrimental they are to the increase of all the fishes among which they live, for it is with the utmost industry, sagacity, and greediness that they seek out and destroy all the young fry that come their way."

Almost 85 per cent of the food consists of fishes of neutral importance.

Least tern (*Sterna antillarum*).—Almost half (43.1 per cent) of the food of 49 least terns consists of silver anchovies (*Stolephorus*). They were captured from New Jersey to Florida and Louisiana in May and June. Menhaden (*Brevoortia tyrannus*) compose 6.8 per cent; mummichogs (*Fundulus*), 6.3 per cent; silversides (*Menidia*), 1.1 per cent; and unidentified fish, 37.7 per cent. The remaining 5 per cent of the food is made up of crustacea. No food fishes were identified from stomachs of the least tern.

Black tern (*Hydrochelidon nigra surinamensis*).—The food of the black tern (fig. 10) is more varied than that of any other species. Fish, chiefly minnows (Cyprinidæ) and mummichogs (*Fundulus*), compose a little more than 19 per cent of the total contents of 145 stomachs. Dragon flies make more than 20 per cent; May flies, 13 per cent; grasshoppers, 12 per cent; predaceous diving beetles, almost 6 per cent; scarabæid beetles, almost 5 per cent; leaf beetles, 3½ per cent; gnats and other flies, more than 8 per cent; crustacea, 3½ per cent. Other items of food are ground-beetles (Carabidæ), click beetles (Elateridæ), weevils, stone flies, caddis flies, water striders, moths, and ants.

The bird preys upon no food fishes, as far as known, but does feed extensively upon such fish enemies as dragon-fly nymphs, dytiscid beetles, and crawfishes. It takes a great variety of insects, including some of economic importance, as the moth of the cotton bollworm and the fall army worm, click beetles (adults of wireworms), weevils, and grasshoppers.

Summary.—The average percentage of food fishes in the regimen of these five species of terns is only 4.8 per cent. This refutes the charge that they live largely on food fishes. Among the other fishes eaten, menhaden are prominent, forming an average of 21 per cent of the food. Since these fish are so enormously abundant that their chief economic value is for fertilizer and oil, hundreds of tons of which are made, the number of them consumed by terns is insignificant. Silvery anchovies (*Stolephorus*) and fresh water minnows (Cyprinidæ) compose about 13 per cent each. These little fishes swarm in shallow waters and are of no direct value to man.

The charge that terns prevent the increase of food fishes by eating the small fishes which are their natural food is wholly unfounded, since there is no scarcity in the food supply, but on the contrary a constant superabundance. In this connection we would point out that some largely herbivorous food fishes, such as the buffalo fishes, with whose food supply the terns have very little to do, have alarmingly decreased, just as have some of the carnivorous ones. The cause of reduction in the number of food fishes is not chiefly failure of the natural food supply, but, as has been pointed out by experts of the United States Bureau of Fisheries, too close fishing.

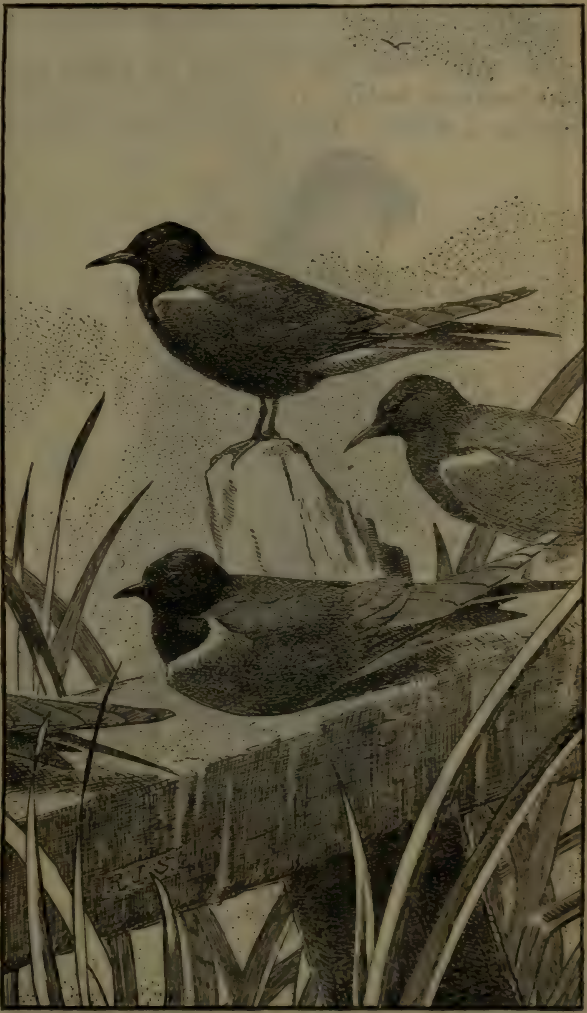


FIG. 10.—Black tern.

The responsibility for the scarcity of certain food fishes, therefore, can not justly be placed upon the terns, especially since it is shown that a very small proportion of their diet is composed of these fishes.

Moreover, it must be remembered to their credit that part of their food consists of economically injurious fishes, and that in the case of some species a considerable proportion of insects is taken, most of which are directly injurious to the fishing industry.—W. L. M.

COOPER'S HAWK.

(*Accipiter cooperi.*)

Cooper's hawk (fig. 11) may be taken as a type of the group of hawks whose habits are responsible for the condemnation of birds of prey as a whole. This group includes three species: Cooper's hawk, the sharp-shinned hawk, and the goshawk. They are often spoken of as blue darters, a name which expresses a characteristic difference in their manner of hunting from that of other hawks. They course over the country at great speed and capture their prey by sudden darts. The blue darters are long-tailed hawks, but they should not be confounded with that other conspicuously long-tailed bird, the marsh hawk. The latter usually flies slowly and may be recognized by the white rump. The red-tailed, red-shouldered, and other large hawks usually watch for their prey from some convenient lookout station or soar slowly over meadow and forest, watching a chance to pounce upon their quarry. These hawks almost always seize their victims on the ground, while hawks of the darter group often take them in full flight. This difference is of course chiefly due to the character of the prey, the darters feeding almost exclusively upon birds, which usually must be caught on the wing, while the other hawks prey upon

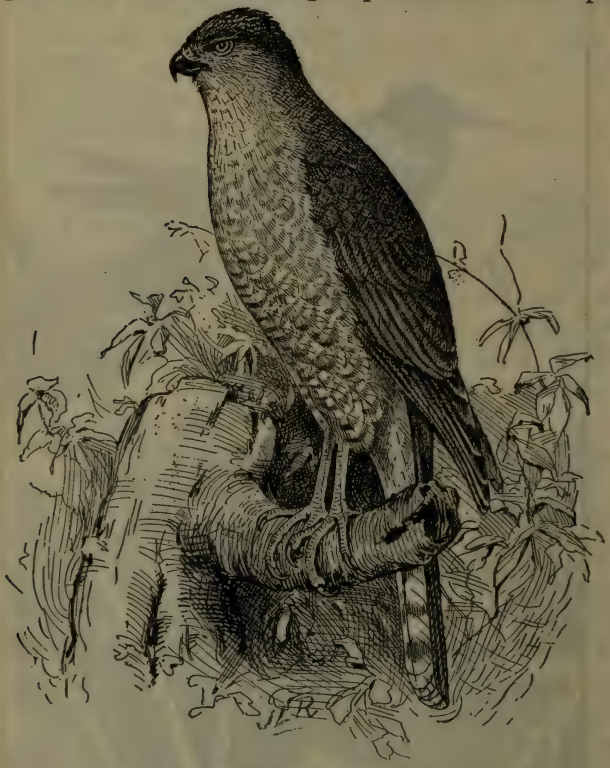


FIG. 11.—Cooper's Hawk.

mice and other small mammals, snakes, and grasshoppers and other insects, which as a rule must be sought on the ground.

Cooper's hawk, which occurs throughout the United States, is preeminently a "chicken hawk," and it is by far the most destructive species we have to contend with, not because it is individually worse than the goshawk, but because it is so much more numerous that the aggregate damage done far exceeds that of all other birds of prey. It is strong enough to carry away a good-sized chicken, grouse, or cottontail rabbit. It is especially fond of domesticated doves and when it finds a cote easy of approach it usually takes a toll of one or two a day. Practically every stomach of Cooper's hawk examined contained remains of wild birds or poultry.—W. L. M.

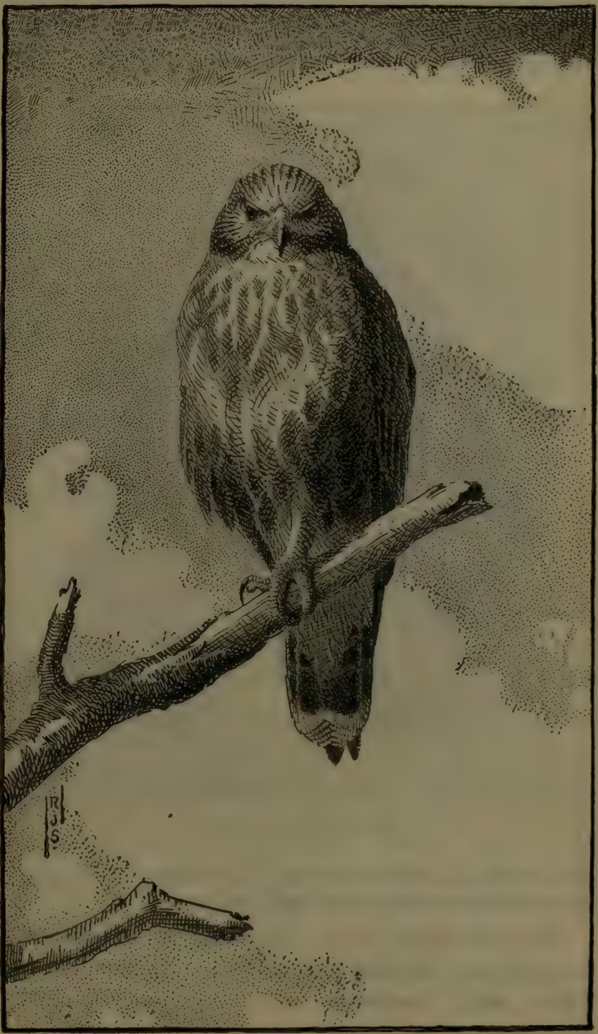


FIG. 12.—Rough-legged hawk.

THE ROUGH-LEGGED HAWK.

(*Archibuteo lagopus sancti-johannis.*)

The rough-legged hawk (fig. 12), whose range, in general terms, is North America north of Mexico, is a representative of the class of almost wholly beneficial hawks. In regard to its habits Dr. Fisher says:

> The rough-leg is one of the most nocturnal of our hawks, and may be seen in the fading twilight watching from some low perch, or beating with measured, noiseless flight,

over its hunting ground. It follows two very different methods in securing its food, one by sitting on some stub or low tree and watching the ground for the appearance of its prey, as the red tail does; the other by beating back and forth just above the tops of the grass or bushes, and dropping upon its victim after the manner of the marsh hawk. Its food consists principally, if not almost exclusively, of the smaller rodents, and most prominent among these are the arvicoline mice and lemmings. As is well known, the meadow mice (*Arvicolæ*) are widely distributed over the north temperate zone, and often occur in immense numbers, overrunning certain sections of country, and doing irreparable damage to crops as well as to fruit and ornamental trees. Repeatedly young orchards, consisting of hundreds of trees, and representing great money value, have been totally destroyed by these pests. The damage is done in winter, under the snow, where the mice eat the bark from the trees, often completely girdling them and causing death. Usually meadow mice are fairly common if not abundant over a large part of the meadow and marsh lands of the central and northern United States and temperate Canada. To show how important meadow mice are to the rough leg as an article of food, it may be stated in general terms that the southern limit of its wandering in winter is nearly coincident with the southern boundary of the region inhabited by meadow mice. In the north lemmings are abundant over the country in which the rough leg makes its summer home, and furnish a never-failing supply of food for old and young.[1]

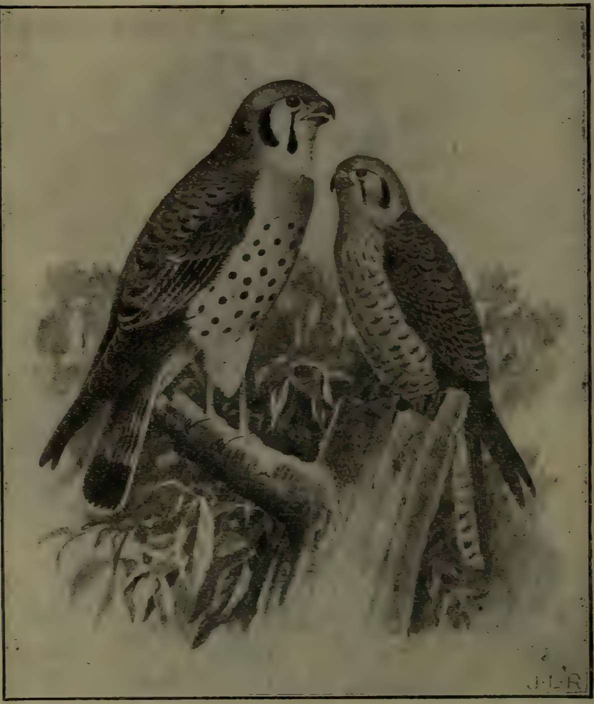


FIG. 13.—Sparrow hawk.

Meadow mice were found in 28 stomachs, 5 or 6 occurring in several, and as many as 12 in 1. A few rats, house mice, shrews, and other small mammals also were found, birds appearing in only 3 stomachs.—W. L. M.

SPARROW HAWK.

(*Falco sparverius.*)

The sparrow hawk (fig. 13) ranges over almost the whole of North America. It is the smallest as well as one of the handsomest of our hawks and one of the best known. It is further distinguished by its swallowlike flight, its habit of hovering over the luckless grasshopper or meadow mouse it hopes to make a meal of, and its repeated shrill wavering cry. "It is the only one of the true falcons," as has been pointed out by Dr. Fisher, "which can be placed in the mainly beneficial class." He says further:

---

[1] Bull. 3, Biological Survey, p. 87, 1893.

> At times it attacks small birds and young chickens, but these irregularities are so infrequent that they are more than outweighed by its good services in destroying insects and mice. Grasshoppers, crickets, and other insects form its principal food during the warm months, while mice predominate during the rest of the year. Terrestrial caterpillars, beetles, and spiders also are eaten to a considerable extent. As might be expected, a large proportion of the birds captured are taken during the nesting season, the hawks then having less time to secure their favorite food. It is at this time also that they commit depredations in poultry yards. During late fall and winter, meadow mice and house mice form a large part of their food, the former being taken in fields and meadows and the latter around corn stacks and about barns and outbuildings. Because of its confidence and lack of fear the sparrow hawk is one of the species which suffers most from unjust bounty laws. Any vandal who can carry a gun is able to slaughter this little hawk. Mr. W. B. Hall, of Wakeman, Ohio, writes us that while the hawk law was in force in Ohio he was township clerk in his native village and issued 86 certificates, 46 being for sparrow hawks. He examined the stomachs and found 45 of them to contain the remains of grasshoppers and beetles, while the remaining one contained the fur and bones of a meadow mouse.[1]

W. L. M.

LONG-EARED OWL.

(*Asio wilsonianus.*)

The long-eared owl occurs throughout the United States. It is nocturnal in its habits and is one of our most beneficial species. Mice, principally meadow mice, are its staple food. One hundred and fifty pellets collected by Dr. Fisher under the roost of a bird of this species at Munson Hill, Va., contained remains of 95 meadow mice, 19 pine mice, 15 house mice, 5 white-footed mice, 3 Cooper's mice, 26 shrews, and 13 birds, of which 11 were sparrows, 1 a bluebird, and the other a warbler. Eighty-six out of 92 stomachs examined also contained mice. The bird is common all over the United States and does a great deal of good. It is not wary, hence is one of the greatest sufferers where bounties are paid for the destruction of birds of prey.—W. L. M.

SCREECH OWL.

(*Otus asio.*)

The little screech owl (fig. 14), in the South aptly called "shivering owl," in allusion to its quavering whistle, or perhaps to the effect of that call upon the listener, ranges from coast to coast and far beyond both the northern and southern boundaries of the United States. With the exception of the burrowing owl it feeds more extensively on insects than any of the other owls. It is also, according to Dr. Fisher—

---

[1] Circ. 61, Biological Survey, p. 9, 1907.

> a diligent mouser, and feeds more or less on crawfish, frogs, toads, scorpions, lizards, and fish. * * * Among insects, grasshoppers, crickets, beetles, and cutworms are most often eaten. As many as 50 grasshoppers have been found in one stomach, 18 May beetles in another, and 13 cutworms in another. During the warmer parts of the year it is exceptional to find a stomach not well filled with insect remains. Meadow mice, white-footed mice, and house mice are the mammals most often taken, while chipmunks, wood rats, flying squirrels, and moles are less frequently found. The screech owl is fond of fish and catches many, especially in winter, when he watches near the breathing holes in the ice, and seizes the luckless fish which comes to the surface. Most of the birds destroyed by this owl are killed either in severe winter weather or during the breeding season, when it has hard work to feed its young. As nearly three-fourths of the owl's food consists of injurious mammals and insects, and only about one-seventh of birds (a large proportion of which are destructive English sparrows), there is no question that this little owl should be carefully protected.[1]

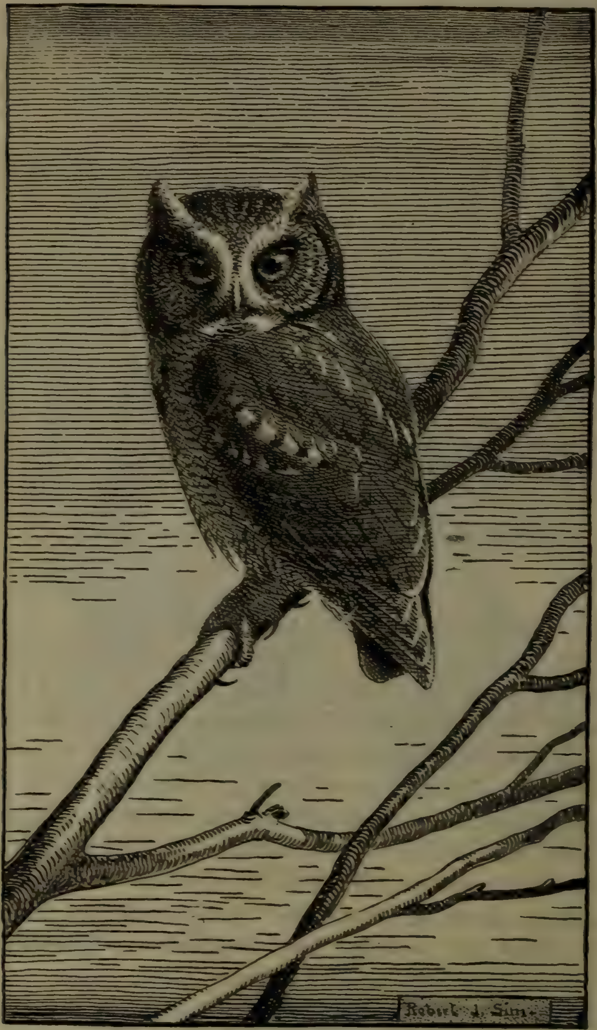


FIG. 14.—Screech owl.

W. L. M.

---

[1] Circ. 61, Biological Survey, pp. 12-13, 1907.

Issued July 30, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

Aug 2 1912

FARMERS' BULLETIN 498.

SUPERSEDED BY 1054

METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

BY

H. W. GRAYBILL, D. V. M.,

Assistant Zoologist, Zoological Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., March 8, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "Methods of Exterminating the Texas-fever Tick," by Dr. H. W. Graybill, assistant zoologist in the Zoological Division of this bureau. This paper is a revision of Farmers' Bulletin 378, issued in 1909.

For many years these ticks, which transmit the disease of cattle known as Texas or tick fever, have been a cause of heavy loss and a great handicap to live-stock raising in the southern part of the United States. The progress so far made, however, in the cooperative campaign by this department and State authorities with the object of completely eradicating this pest from the country demonstrates that it is entirely possible to accomplish that result, although a number of years of hard work will be required. It is of great importance for the success of this undertaking that the efforts of the officials should be supplemented by individual work by the farmers. This paper gives simple and practical directions for exterminating the ticks, and I respectfully recommend its publication in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	5
Progress in tick eradication	5
Reasons for eradicating the cattle tick	6
Life history of the tick	10
Development on the ground	11
Development on cattle	13
Summary of life history	13
Methods of eradication	14
Pasture rotation	14
Time required to kill ticks by starvation	14
Time required to free cattle of ticks on uninfested fields	16
Freeing cattle of ticks by rotation on tick-free land	17
Freeing both cattle and pastures of ticks by the rotation method	18
Dipping, spraying, and hand dressing	25
Crude petroleum	25
Emulsions of crude petroleum	26
Arsenical dips	27
Precautions in the use of arsenic	31
Procedure in dipping and spraying	33
Rule for calculating the capacity of a dipping vat	36
Specifications for the construction of a concrete cattle-dipping vat	37

ILLUSTRATIONS.

Page.

FIG. 1. Map showing areas quarantined on account of Texas fever and areas freed from ticks.... 7
2. Tick-infested steer before dipping; weight 730 pounds.... 8
3. Same steer two months after being freed of ticks; weight 1,015 pounds.. 9
4. Full-grown female tick, engorged and ready to drop to ground and deposit eggs.... 12
5. Tick laying eggs.... 12
6. Larvæ or seed ticks after emerging from eggs.... 12
7. Young ticks before and after first molt.... 12
8. Young tick (nymph) near second molt.... 12
9. Male tick.... 12
10. Female tick after second molt.... 12
11. Plan for freeing cattle and pastures from ticks by rotation, requiring four and one-half months.... 20
12. Plan for freeing cattle and pastures from ticks by rotation, requiring eight months.... 21
13. Plan for freeing cattle and pastures from ticks by rotation, requiring four months, with a new pasture.... 23
14. Plan for freeing cattle and pastures from ticks by rotation; feed-lot or soiling method.... 24
15. Dipping cattle.... 34
16. Pail spraying pump for small herds.... 35
17. Oil can used with spraying pump.... 36
18. Convenient method of holding nozzle in spraying.... 37
19. Plans for a concrete dipping vat.... 38

METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

INTRODUCTION.

The eradication of the cattle tick (*Margaropus annulatus*) from the Southern States is a problem of prime importance to the agricultural interests of that section. The elimination of the tick would give a tremendous impulse to the cattle and dairy interests of the South, place southern agriculture on a more scientific and profitable basis, and, as a consequence, give a greater measure of prosperity to the South as a whole. Although the extermination of the tick would be of the greatest benefit to those States in which the tick now occurs, the benefits resulting therefrom would not be confined to them, but would be enjoyed to a greater or less extent by the rest of the country, in consequence of which the problem becomes, to a certain degree, one of national importance.

A number of valuable papers on the life history of the cattle tick, its habits, and methods for its eradication have been published by the United States Department of Agriculture and by various investigators in the States included within the infested region. Some of these publications are rather extensive and include much that is only of scientific interest, while others, of a more or less practical nature, are not available for general use. The present bulletin is prepared with the view of bringing together from these various sources information of practical value relating to the tick and its eradication, for the use of the farmer or stockman who has begun or who contemplates undertaking the complete extermination of this pest from his farm.

PROGRESS IN TICK ERADICATION.

During the past six years the Bureau of Animal Industry has been conducting tick-eradication work in all of the States of the infested region except one, in cooperation with the State authorities. During this time (from 1906 up to April 15, 1912) 162,648 square miles have been rendered free of ticks and relieved from the restrictions placed on infested territory by the national quarantine measures against splenetic fever, and in a considerable additional area the work of eradication is well under way. The area which has been rendered free exceeds the combined areas of the States of Georgia, Alabama, and Mississippi. This record alone should be ample proof of the feasibility of ultimately eradicating the tick from the infested area, and is evidence of the efficacy of the methods adopted. The methods will undoubtedly be improved upon from time to time as new facts become available as a result of further investigations, but it may be stated that they have reached such a degree of perfection and have been given such a wide practical test, especially those that involve a treatment of the animals, that the question of how to eradicate ticks successfully is no longer an essential part of the problem, and the main part of the task is to enlist a hearty, vigorous, and conscientious cooperation on the part of the people. In other words, the work will progress from now on just as rapidly as the people desire that it should.

REASONS FOR ERADICATING THE CATTLE TICK.

There are various kinds or species of ticks occurring on cattle in the Southern States, but the one that chiefly concerns us here is that commonly called the "cattle" or "Texas-fever" tick (*Margaropus annulatus*). It is the one most frequently found on cattle, and is much more abundant than the other species. When the losses occasioned by this parasite are once thoroughly understood by farmers and stockmen there will be little need for arguments in favor of tick eradication. Some of the losses are not directly noticeable and consequently make little impression, while other losses properly chargeable to the tick are frequently attributed to other causes.

It is hardly necessary to emphasize the fact that the tick is something more than a simple parasite drawing blood from its host, it being the carrier of a dangerous microorganism, or germ, which it transmits to the blood of cattle, thus causing a disease known by many names, among which are Texas fever, tick fever, splenetic fever, and murrain.[1] Without the tick there can be no Texas fever, and it is by preventing the spread of the tick beyond its natural bounds that the fever has been prevented from waging destruction among northern cattle, which are especially susceptible to the disease. In order to restrict the distribution of the tick the National and State governments maintain a quarantine line extending across the country from the coast line of southern Virginia to the southern boundary of Texas, and also running across the southwestern part of California, marking the boundary between the States or portions of States harboring this pest and those that do not (fig. 1). Cattle of the quarantined area can not be driven across this line and may be shipped only in accordance with the regulations of the Secretary of Agriculture to prevent the spread of splenetic fever of cattle.

---

[1] For information as to this disease and how it is transmitted by the ticks the reader is referred to Farmers' Bulletin 258, "Texas or Tick Fever and Its Prevention."

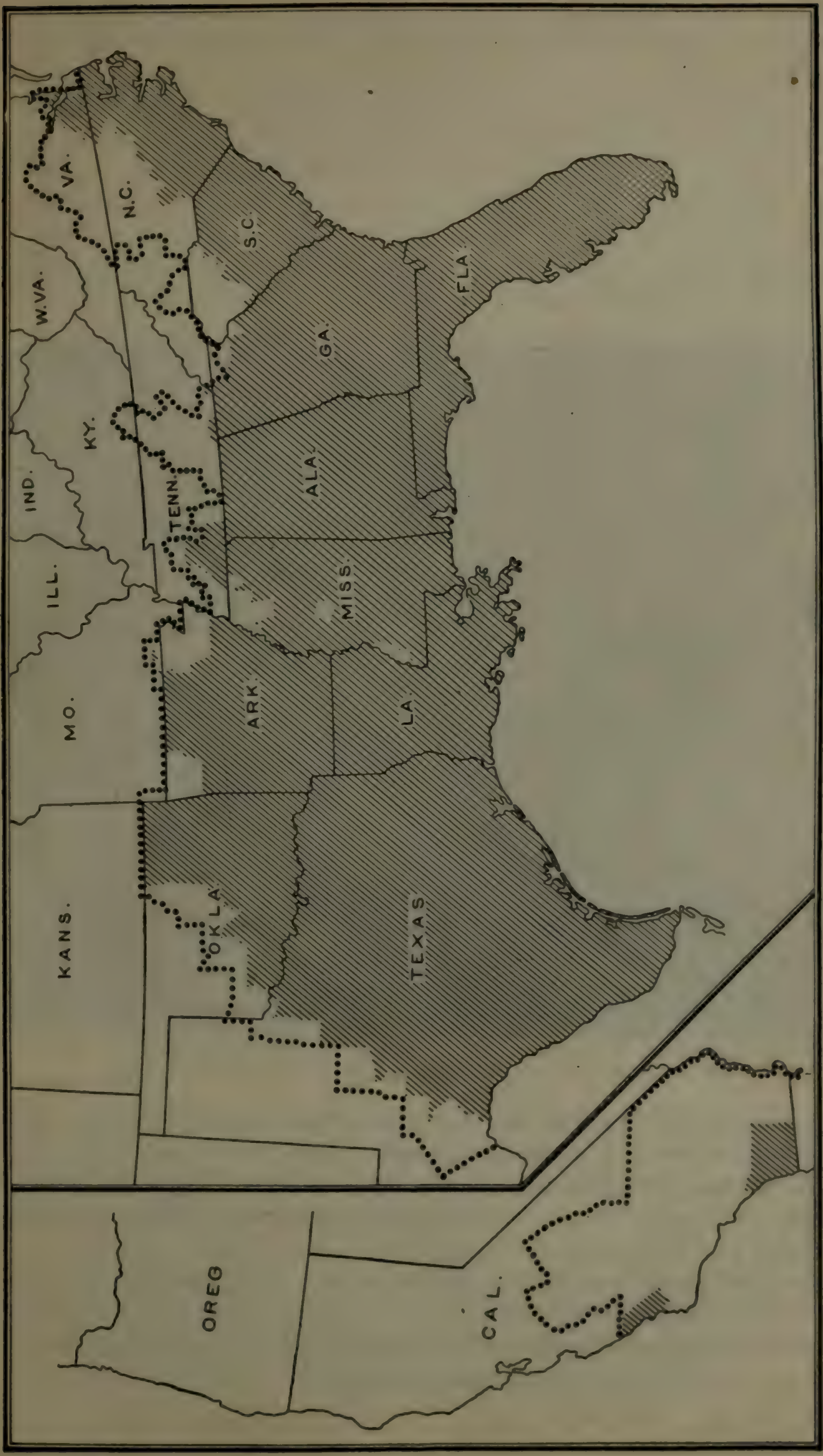


FIG. 1.—Map showing areas quarantined on account of Texas fever and areas freed from ticks. Shaded portions indicate areas under quarantine; dotted lines show boundary of infected area at beginning of tick eradication in 1906; white areas below dotted line indicate territory that has been freed from ticks and released from quarantine.

Every year each locality in the tick-infested area pays its toll to the tick in cattle dead from Texas fever. The truth of this is very soon impressed on anyone who knows something of the symptoms and lesions of Texas fever and has had occasion to observe cattle from time to time in the South. In fact, many of the more intelligent farmers now recognize that they suffer more or less regular losses from Texas fever. The yearly loss of native cattle in the infested region can not be determined with any degree of certainty, but there is little doubt that if the losses were known and summed up the total would be astonishingly large. In addition to the loss of native cattle, the loss of purebred cattle brought into the tick country for breeding purposes is another item that must be considered. Unless cattle brought from outside the tick area have been immunized against Texas fever the death rate is very high, reaching as much as 90 per cent.

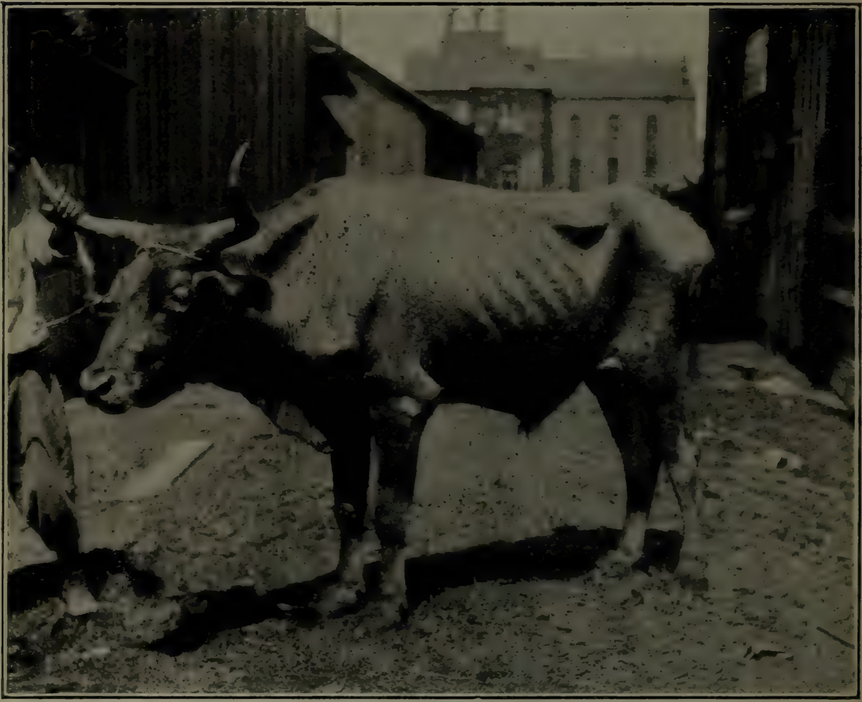


FIG. 2.—Tick-infested steer before dipping, August 12, 1911; weight 730 pounds.

Another item of loss that must be taken into consideration, although it does not directly affect the infested States, is the death of cattle north of the quarantine line, due to the accidental introduction of the tick on cattle from the quarantined area.

With regard to cattle that survive an attack of fever, it should be said that their growth and development are frequently arrested for some time following the attack, or even permanently arrested, resulting in the production of dwarfed or stunted animals that can not prove profitable to the owner. Even in the case of cattle that have survived an attack of Texas fever, whether they have suffered any great injury therefrom or not, the presence of any considerable number of ticks on them must be regarded as a great drain on the animal economy, increasing the amount of feed required by each animal and requiring a greater expenditure of energy on the part of the animal in obtaining, digesting, and assimilating the additional food required. In consequence of this drain the rate of putting on flesh in the case of beef cattle is reduced and the amount of milk produced by dairy cattle is diminished.

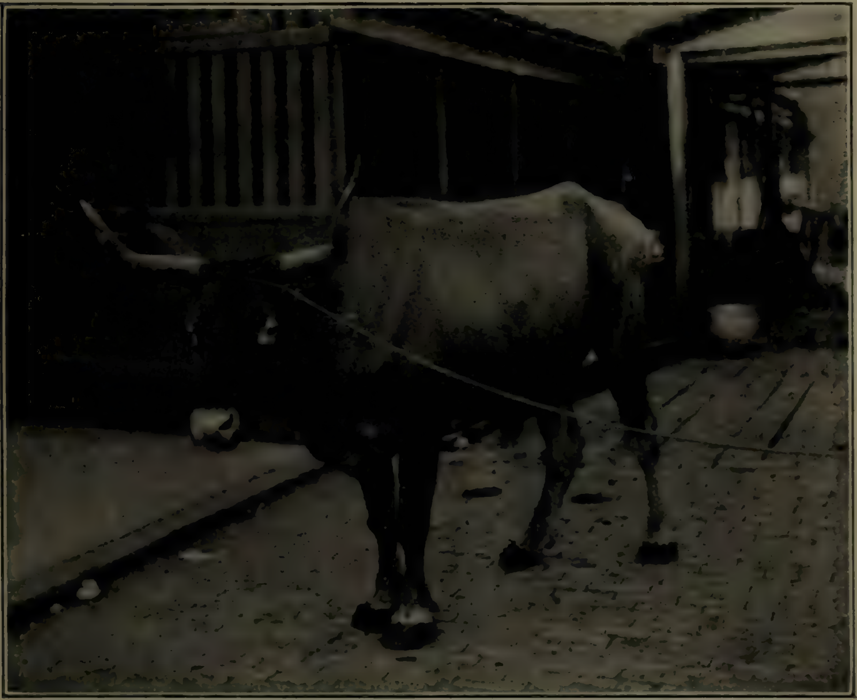


FIG. 3.—Same steer as shown in figure 2, October 12, 1911, two months after being freed of ticks; weight 1,015 pounds.

The tick prevents southern breeders from exhibiting their cattle in the North and likewise prevents or interferes seriously with northern breeders exhibiting their purebred cattle in the infested area. The latter restriction has no doubt played an important part in retarding the improvement of southern cattle.

Another source of considerable loss is due to the lower price brought generally by southern cattle on the market because of the restrictions placed on them. In addition to this there should be noted the expense incurred by transportation companies in conforming to the regulations governing the interstate movement of cattle from the infested region and that incurred by the Federal Government and the infested States in establishing quarantine lines and enforcing regulations to prevent the spread of Texas fever.

The total annual loss due to the tick has been estimated by various writers at $40,000,000 to $100,000,000. These figures should be ample argument, even to the most conservative, for the eradication of the tick.

The South needs more and better live stock and a larger and better dairy industry, and these objects would both be greatly promoted by the destruction of the tick. Furthermore, the increased production of live stock, by reason of its important bearing in maintaining and improving the fertility of the soil, would be of distinct benefit in increasing the yield of field crops. An incidental, though important, advantage of stock raising and dairying would be found in the distribution of the farmer's income throughout the year, enabling him to live on a cash basis. It can thus be seen that the benefits which would accrue to southern agriculture from the extermination of the cattle tick would be very great and far-reaching.

An example of the benefits of tick eradication is afforded by the Mississippi steer shown in figures 2 and 3. This steer when infested with ticks weighed only 730 pounds on August 12, 1911. He was freed of ticks by dipping on that date, and two months later (Oct. 12) his weight had increased to 1,015 pounds. The feed in the meantime was the same as before. The steer thus gained 285 pounds in two months after being freed of ticks, an average daily gain of 4⅔ pounds.

LIFE HISTORY OF THE TICK.

Before methods of eradication can be carried out intelligently and successfully it is necessary to know the life history of the tick and the influence of temperature, moisture, and other climatic conditions on the various stages of its existence. These matters will therefore be taken up first, it being understood that whenever the term "tick" or "cattle tick" is used it refers to the one species or kind, *Margaropus annulatus*.[1]

Cattle are the usual hosts for this tick. Frequently, however, horses, mules, deer, and sometimes even buffaloes and sheep serve as hosts. But none of these latter animals, with the possible exception of deer and buffaloes, are susceptible to tick fever, consequently they suffer from the tick as a simple parasite and not as a transmitter of disease, although they must be considered in plans for eradication.

---

[1] The reader desiring fuller information as to the life history of the cattle tick is referred to Bulletin 72, of the Bureau of Entomology, and Bulletin 130, Bureau of Animal Industry, U. S. Department of Agriculture, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 and 10 cents, respectively.

Only a part of the development of the tick takes place on the host; the rest of the development occurs on the pasture occupied by the host.

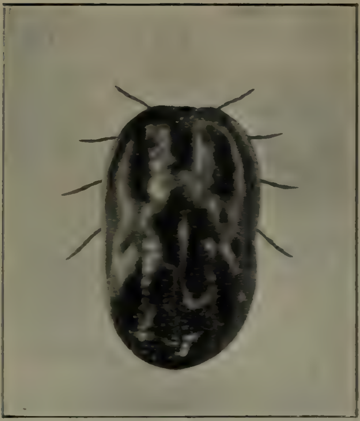
DEVELOPMENT ON THE GROUND.

In tracing the life history of the cattle tick it will be convenient to begin with the large, plump, olive-green female tick (fig. 4), about half an inch in length, attached to the skin of the host. During the few preceding days she has increased enormously in size, as a consequence of drawing a large supply of blood.

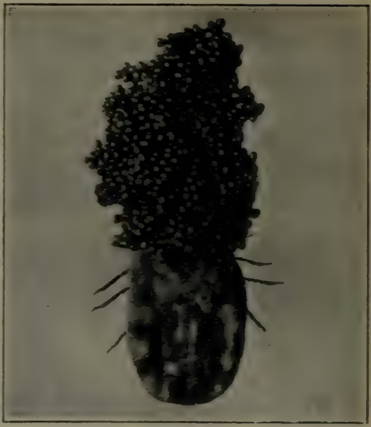
When fully engorged she drops to the ground, and at once, especially if the weather is warm, begins to search for a hiding place on moist earth beneath leaves or any other litter which may serve as a protection from the sun and numerous enemies or shield her from unfavorable conditions. The female tick may be devoured by birds, or destroyed by ants, or may perish as the result of unfavorable conditions, such as low temperature, absence or excess of moisture, and many other conditions; so that many which fall to the ground are destroyed before they lay eggs.

Egg laying (see fig. 5) begins during the spring, summer, and fall months in from 2 to 20 days, and during the winter months in from 13 to 98 days, after falling to the ground. The eggs are small, elliptical-shaped bodies, at first of a light amber color, later changing to a dark brown, and are about one-fiftieth of an inch in length. As the eggs are laid they are coated with a sticky secretion which causes them to adhere in clusters and no doubt serves the purpose of keeping them from drying out. During egg laying the mother tick gradually shrinks in size and finally is reduced to about one-third or one-fourth her original size. Egg laying is greatly influenced by temperature, being retarded or even arrested by low temperatures. It is completed in from 4 days in the summer to 151 days beginning in the fall. During this time the tick may deposit from a few hundred to more than 5,000 eggs. After egg laying is completed the mother tick has fulfilled her purpose and dies in the course of a few days.

After a time, ranging from 19 days in the summer to 188 days during the fall and winter, the eggs begin to hatch. From each egg issues a small, oval, six-legged larva or seed tick (fig. 6), at first amber colored, later changing to a rich brown. The seed tick, after crawling slowly over and about the shell from which it has emerged, usually remains more or less quiescent for several days, after which it shows great activity, especially if the weather is warm, and ascends the nearest vegetation, such as grass, other herbs, and even shrubs.

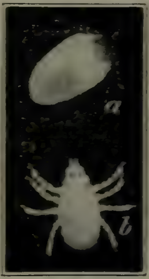


4



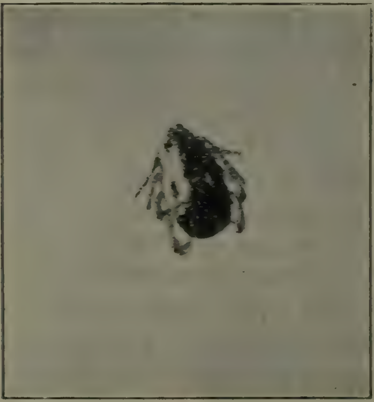
5

6



7

8



9

10

Figs. 4 to 10.—Cattle ticks in various stages. 4. Full-grown female tick, engorged and ready to drop to ground and deposit eggs. (Magnified 3 times.) 5. Tick laying eggs. One tick may lay as many as 5,000 eggs. (Magnified 3 times.) 6. Larvæ or seed ticks after emerging from eggs. (Magnified 8 times.) 7. Young ticks before (*a*) and after (*b*) first molt. At this stage the ticks have attached themselves to a host (cow, steer, etc.) and have changed from a brown color to white. It will be noticed that the tick has six legs before molting and eight afterwards. (Magnified 9 times.) 8. Young tick nearly ready to undergo the second molt. The tick at this stage is known as a nymph. (Magnified 8 times.) 9. Male tick. (Magnified 8 times.) 10. Female tick after second molt. This tick is now sexually mature and slightly larger than the male, but will later greatly increase in size until ready to drop to the ground and deposit eggs. (Magnified 8 times.)

Since each female lays an enormous mass of eggs at one spot, thousands of larvæ will appear in the course of time at the same place and will ascend the near-by vegetation and collect on the leaves and other parts of plants. This instinct of the seed ticks to climb upward is a very important adaptation to increase their chances of reaching a host. If the vegetation upon which they rest is disturbed they become very active and extend their long front legs upward in a divergent position, waving them violently in an attempt to seize hold of a host.

The seed tick during its life on the pasture takes no food and consequently does not increase in size, and unless it reaches a host to take up the parasitic portion of its development, it dies of starvation. The endurance of seed ticks is very great, however, as they have been found to live nearly eight months during the colder part of the year.

DEVELOPMENT ON CATTLE.

The parasitic phase of development begins when the larvæ or seed ticks reach a favorable host, such as a cow. They crawl up over the hair of the host and commonly attach themselves to the skin of the escutcheon, the inside of the thighs and flanks, and to the dewlap. They at once begin to draw blood and soon increase in size. In a few days the young tick changes from a brown color to white (fig. 7, *a*), and in from 5 to 12 days sheds its skin. The new form has eight legs instead of six and is known as a nymph (fig. 7, *b*, and fig. 8).

In from 5 to 11 days after the first molt the tick again sheds its skin and becomes sexually mature. It is at this stage that males and females are with certainty distinguishable for the first time. The male (fig. 9) emerges from his skin as a brown, oval tick, about one-tenth of an inch in length. He has reached his growth and goes through no further development. He later shows great activity, moving about more or less over the skin of the host. The female (fig. 10) at the time of molting is slightly larger than the male. She never shows much activity, seldom moving far from her original point of attachment. She still has to undergo most of her growth. After mating the female increases very rapidly in size, and in from 21 to 66 days after attaching to a host as a seed tick she becomes fully engorged (fig. 4) and drops to the pasture, to start again the cycle of development by laying eggs.

SUMMARY OF LIFE HISTORY.

To sum up, on the pasture there are found three stages of the tick—the engorged female, the egg, and the larva or seed tick; and on the host are also found three stages—the larva or seed tick, the nymph, the sexually mature adult of both sexes, and in addition the engorged condition of the female.

METHODS OF ERADICATION.

In undertaking measures for eradicating the tick it is evident that the pest may be attacked in two locations, namely, on the pasture and on the cattle.

In freeing pastures the method followed may be either a direct or an indirect one. The former consists in excluding all cattle, horses, and mules from pastures until all the ticks have died from starvation. The latter consists in permitting the cattle and other animals to continue on the infested pasture and treating them at regular intervals with agents destructive to ticks and thus preventing engorged females from dropping and reinfesting the pasture. The larvæ on the pasture, or those which hatch from eggs laid by females already there, will all eventually meet death. Such of these as get upon the cattle from time to time will be destroyed by the treatment, while those which fail to find a host will die in the pasture from starvation.

Animals may be freed of ticks in two ways. They may be treated with an agent that will destroy all the ticks present, or they may be rotated at proper intervals on tick-free fields until all the ticks have dropped.

PASTURE ROTATION.

TIME REQUIRED TO KILL TICKS BY STARVATION.

The time required for the ticks to die out after all animals have been removed from infested fields and pastures varies considerably, depending principally on the climate and the weather. The dates when pastures will be free of ticks, beginning during each month of the year, are given in the following table:

TABLE I.—*Time required to free pastures from ticks by starvation.*

Date of removal of all animals from pasture.	Date when pasture will be free from ticks.	Date of removal of all animals from pasture.	Date when pasture will be free from ticks.
July 1	March 1.	December 15 to March 15, inclusive.	September 1.
August 1	May 1.	April 1	September 15.
September 1	July 1.	April 15	October 15.
October 1 to November 1, inclusive	August 1.	May 1 to June 15, inclusive	November 1.
December 1	August 15.		

The above table is based on investigations by Hunter and Hooker[1] at Dallas, Tex., and by the writer[2] at Auburn, Ala., under cooperation between the Bureau of Animal Industry and the veterinary department of the Alabama Polytechnic Institute. All the periods obtained by Newell and Dougherty (1906)[3] in work carried on at Baton Rouge, La., which is much farther south, are shorter. The periods given in Table I should be found ample for all localities lying no farther north than Dallas, Tex., or Auburn, Ala.

---

[1] Bulletin 72, Bureau of Entomology, U. S. Department of Agriculture.

[2] Bulletin [illegible], Bureau of Animal Industry, U. S. Department of Agriculture.

[3] Circular 10, State Crop Pest Commission of Louisiana.

In general, moisture and cold prolong and dryness and heat shorten the duration of an infestation. If various portions of the same pasture differ with regard to temperature and moisture, as is frequently the case, some parts become free of ticks before others do. Other things being equal, high, dry, unshaded land becomes tick free sooner than low, damp, shady land. Land, however, that is supplied with an excessive amount of moisture and is extremely shady, as along some river bottoms, is not likely to be a favorable breeding place for the cattle tick, and low lands that are subjected to more or less regular overflows, if infested at all, are, as a rule, only lightly infested.

The time required for freeing pastures in the southern part of the infested area may be considerably less in many localities than that indicated in Table I, yet, in view of the fact that we are not in possession of ample data as to what the lengths of periods should be, the simplest and safest plan will be to follow the table in the region indicated for it. There is little doubt that the periods are longer for the majority of localities in the northern half of the infested area. Mr. E. C. Cotton[1] obtained at Knoxville, Tenn., during the years 1907 to 1909, inclusive, periods considerably longer than those given in Table I. Table II is based on the records obtained at Knoxville.

TABLE II.—*Time required to free pastures from ticks by starvation.*

Date of removal of all animals from pasture.	Date when pasture will be free from ticks.	Date of removal of all animals from pasture.	Date when pasture will be free from ticks.
January 1	August 1.	June 15	May 1.
February 1 to March 15	November 15.	July 1	June 15.
April 1 to 15	January 1.	July 15	July 1.
May 1	January 15.	August 1 to 15	July 15.
May 15 to June 1	February 15.	September 1 to October 1	September 15.

While there can be little doubt that the periods are considerably longer at Knoxville than farther south, it is likely that the above periods are much more than ample for the starvation of ticks under natural conditions. It appears that the work at Knoxville has been conducted by using incubation tubes provided with sand and regularly supplied with moisture. It has been found in our experiments in which such tubes, and also field plots representing natural conditions, were utilized in studying the tick, that the periods obtained with the tubes are longer than those occurring under natural conditions. The above table is given, however, for those living in the northern half of the infested region who may desire to use periods that undoubtedly are ample.[1]

---

[1] Bulletin 94, Agricultural Experiment Station of the University of Tennessee.

According to experiments conducted by Mr. Cotton,[2] the normal duration of an infestation may be considerably shortened or even suddenly brought to an end in infested pastures and fields by the occurrence of exceptionally low temperatures. He found that a certain per cent of engorged females are destroyed by a temperature of 23° F., that all engorged females are destroyed by a temperature of 14° F. when not provided with a protective covering, and that ticks provided with a covering of dry chaff were able to survive a temperature of 12° F., but if the covering is wet they are killed as readily as when unprotected. It was also found that ticks that have deposited some eggs are much more readily destroyed than those that have not begun to oviposit. In addition to this it was demonstrated that all unprotected eggs and all seed ticks are destroyed at temperatures of 4° and 2° F., respectively, but that eggs protected by dry litter can endure a much colder temperature. It is thus seen that the infestation of fields may be greatly reduced during cold spells and may, if the temperature falls to about zero, be entirely destroyed. In case the temperature falls only to a point where all the females are destroyed, the only result accomplished will be a shortening of the period of infestation.

It would be well for stock owners to take advantage as far as practicable of cold spells in which zero weather occurs in freeing their places of ticks. It should be remembered, however, in doing this, that cattle even during the coldest weather are likely to harbor ticks and these will be unaffected by the low atmospheric temperature. These ticks when they drop will reinfest the place; consequently, when a spell of zero weather occurs, if the cattle are not on the fields, pastures, or ranges they should not be returned to the same until freed of ticks, or if at pasture they should be removed at once and not returned until rendered free of ticks by one of the methods suggested later in this bulletin.

TIME REQUIRED TO FREE CATTLE OF TICKS ON UNINFESTED FIELDS.

Before discussing plans for rendering farms tick free, involving the use of the information given in Table I, it will be necessary to indicate how animals may be entirely freed from ticks by placing them on uninfested fields. This is based on the fact that the female tick must drop from the host to the ground before eggs can be laid and before young ticks will develop.

---

[1] In the same bulletin, Part II, in which Mr. Cotton's results are given (Bulletin 94, Agricultural Experiment Station of the University of Tennessee), Mr. J. F. Voorhees, under the title of "Relation of climate to life history," has published periods beginning with the 1st of each month of the year for 27 localities in the tick-infested area, and has given a map for each month of the year, having lines running through localities possessing periods of approximately the same duration. Such data would be of great value in tick eradication, but since the validity of the method used by Mr. Voorhees has not been satisfactorily established, it is not thought wise to include his results at this time.

[2] Loc. cit.

The shortest time in which seed ticks will appear after engorged females have been dropped is 20 days. Consequently, cattle placed on a tick-free field during the warmer part of the year are not in danger of becoming infested again with young ticks until 20 days have elapsed. The time required for all the ticks to drop after cattle have been placed on uninfested land varies with the temperature. It is much longer during the winter than during the summer. The time required, beginning at various times of the year, is given in Table III.

TABLE III.—*Time required for all ticks to drop from cattle placed on tick-free land.*

When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—	When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—
August	Six weeks.	March	Seven weeks.
September	Do.	April	Six weeks.
October	Eight weeks.	May	Do.
November	Nine weeks.	June	Do.
January	Ten weeks.	July	Five weeks.
February	Seven weeks.		

FREEING CATTLE OF TICKS BY ROTATION ON TICK-FREE LAND.

The plan of freeing cattle of ticks by rotating them from one lot or field to another is as follows: Beginning at any time of the year from March to September, inclusive, in the southern half of the infested area, the cattle are removed from the tick-infested pasture they have been occupying to a tick-free lot or field and continued there for not more than 20 days. During this time a considerable number of ticks will drop. In order to prevent the cattle from becoming reinfested (by seed ticks resulting from eggs laid by females that have dropped), the herd is then changed to a second tick-free inclosure for 20 days longer, and if they are not free of ticks by that time, they are placed in a third tick-free inclosure for 20 days more. Should the two changes at intervals of 20 days have been made, 60 days will have elapsed, which is ample time for all ticks to have dropped during the portion of the year indicated, and the animals are ready to be placed on a tick-free pasture or field without danger of becoming reinfested. The periods to free cattle (given in the above table) are believed to be ample. It will, however, be a wise precaution to make a careful examination of the cattle for ticks before placing them in the noninfested field they are to occupy.

During the part of the year from October to February, inclusive, the time required for seed ticks to appear after females have dropped is much longer than the time necessary for all the ticks to drop from cattle. Consequently, if it is desired, the herd may be continued on the same field for the required length of time without danger of becoming reinfested. (According to the data obtained at Knoxville, the period during which cattle may be placed on tick-free land to drop all their ticks without danger of reinfestation is somewhat longer than for the southern part of the infested region, extending from September to March, inclusive, instead of from October to February, inclusive.)

In Table IV the approximate dates when ticky cattle will be in danger of reinfestation when placed on tick-free land at various times of the year have been given. The first section will probably apply to most localities in the southern half of the infested region, and the second section to localities having temperature conditions approximately the same as at Knoxville, Tenn.

TABLE IV.—*Dates seed ticks will appear after ticky cattle have been placed on tick-free land.*

BASED ON DATA OBTAINED AT BATON ROUGE, LA., AUBURN, ALA., AND DALLAS TEX.

Date cattle placed on tick-free pastures.	Date seed ticks will appear.
Jan. 1 to Feb. 4, inclusive	Apr. 24.
Mar. 3	May 3.
Apr. 15	May 20.
May 1	June 5.
June 5	June 28.
July 1	July 25.
Aug. 5	Aug. 30.
Sept. 1	Oct. 7.
Oct. 1	Feb. 25.
Nov. 1 to Dec. 15, inclusive	Mar. 3.

BASED ON DATA OBTAINED AT KNOXVILLE, TENN.

Date cattle placed on tick-free pastures.	Date seed ticks will appear.
Jan. 11 to Mar. 4, inclusive	May 29.
Apr. 1	June 3.
May 15	June 20.
June 12	July 19.
July 3	Aug. 2.
Aug. 6	Sept. 6.
Sept. 4	Apr. 14.
Oct. 2	May 20.

FREEING BOTH CATTLE AND PASTURES OF TICKS BY THE ROTATION METHOD.

The particular scheme of rotation to be followed on a farm depends much on the conditions which have to be met. In figures 11 to 14 four plans of rotation are represented.[1] In these diagrams no attempt has been made to indicate, except in a very rough way, the relative size of the fields, since this depends on the number of cattle and on various conditions of a more or less local nature. It rests with the farmer to select his fields with regard to location and size so as to carry out properly and successfully the plan which he adopts.

---

[1] These plans are based on the periods given in Table I, and are therefore applicable only to the region covered by that table.

The dissemination of ticks requires brief attention before taking up the consideration of rotation methods. Although this seems to be of much importance when considered from a theoretical standpoint, in practice it does not assume the same degree of importance. It seems to be the general opinion of those engaged in the actual tick-eradication work that ticks are not often spread from field to field or from farm to farm except through the agency of ticky animals. It will, nevertheless, be well to record the possible ways in which ticks might be spread from farm to farm, in order that precautions may be taken against this in cases in which it seems especially desirable or necessary to do so.

It is known from experimental work that engorged females and seed ticks do not crawl more than a few feet on a pasture, yet if they should happen to be near a dividing fence they might crawl from one pasture or field to another. Seed ticks might in certain instances during heavy winds be blown across a dividing line from one pasture to another, and it is conceivable that occasionally engorged ticks might drop from the heads of animals reaching through a dividing fence. The danger of ticks being disseminated in these ways may be practically eliminated by constructing a double fence with an intervening space of 15 feet. It is possible that at times dogs, cats, and other animals which ordinarily pass unhindered over farms may carry seed ticks, that have temporarily lodged on their coats, from field to field. The danger, however, of ticks being spread in this way is in all probability very slight.

It is entirely possible for engorged females, eggs, and seed ticks to be carried from a pasture by running water and lodged in another place without being injured in any way. The danger from this source is probably greatest where there are many small streams subject to frequent floods of short duration and on hillsides where the water runs off with great force during heavy rains.

Plan requiring four and one-half months.—The plan of rotation represented in figure 11 requires four and a half months for its completion. Some time during the spring the pasture is divided in the middle by two lines of temporary fence 15 feet apart. The herd is first confined in field No. 1A. On June 15 it is removed from this portion of the pasture to the other portion, designated field No. 1B, and on September 2 is moved to field No. 2A. The cattle are permitted to remain 20 days on each of the fields designated 2A, 2B, and 3. At the end of this time (Nov. 1) all the ticks on the cattle hav
dropped, and the herd is returned to field No. 1A, which in the me
time has become free of ticks. Later, if it is desired, the cattl
be placed in field No. 4. They should not, however, be re
any of the other fields or driven across them, since these

with ticks. Field No. 1B will be free from ticks July 1 of the following year, at which time the temporary double fence may be removed and the cattle allowed to graze over the entire pasture. The rest of the farm will be free of ticks by August 1. If found desirable, the herd may be continued longer in field No. 3, even as late as February

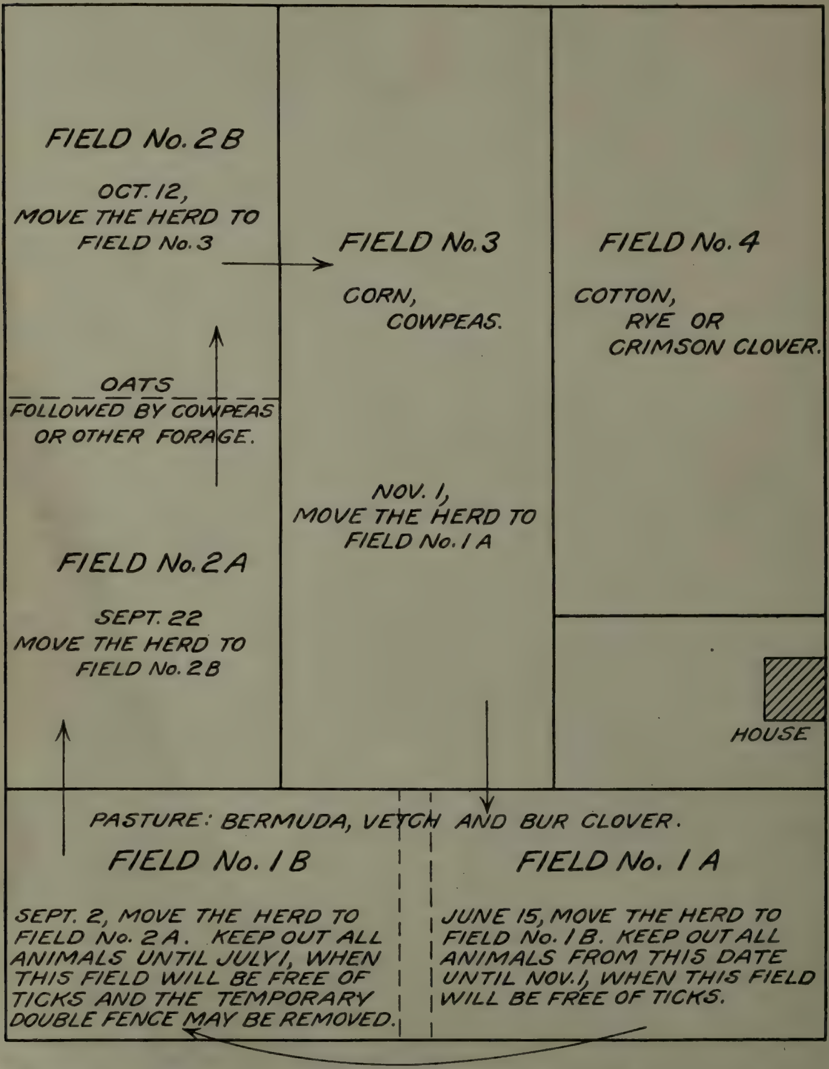

FIELD No. 2B
OCT. 12, MOVE THE HERD TO FIELD No. 3
OATS FOLLOWED BY COWPEAS OR OTHER FORAGE.
FIELD No. 2A
SEPT. 22 MOVE THE HERD TO FIELD No. 2B
FIELD No. 3
CORN, COWPEAS.
NOV. 1, MOVE THE HERD TO FIELD No. 1 A
FIELD No. 4
COTTON, RYE OR CRIMSON CLOVER.
HOUSE
PASTURE: BERMUDA, VETCH AND BUR CLOVER.
FIELD No. 1 B
SEPT. 2, MOVE THE HERD TO FIELD No. 2A. KEEP OUT ALL ANIMALS UNTIL JULY 1, WHEN THIS FIELD WILL BE FREE OF TICKS AND THE TEMPORARY DOUBLE FENCE MAY BE REMOVED.
FIELD No. 1 A
JUNE 15, MOVE THE HERD TO FIELD No. 1B. KEEP OUT ALL ANIMALS FROM THIS DATE UNTIL NOV. 1, WHEN THIS FIELD WILL BE FREE OF TICKS.

Fig. 11.—Plan for freeing cattle and pastures from ticks by rotation, requiring four and one-half months.

the only objection to this being that it will break the crop rota- preventing the sowing of oats in the fall.

l, when practicable, to have double fences with an inter- between the different fields in order to prevent the ticks field to another. If this is not possible on account of the expense and time required to build the extra line of fence, the next best thing to do is to throw up several furrows with a plow on each side of the dividing fences.

When there are streams running through the farm or the slope of the land is considerable, so that ticks may be washed from one field to the other during rains, the fields should be so arranged or selected that the drainage is from field No. 1A to No. 1B, and from field No. 3 toward fields Nos. 2A and 2B.

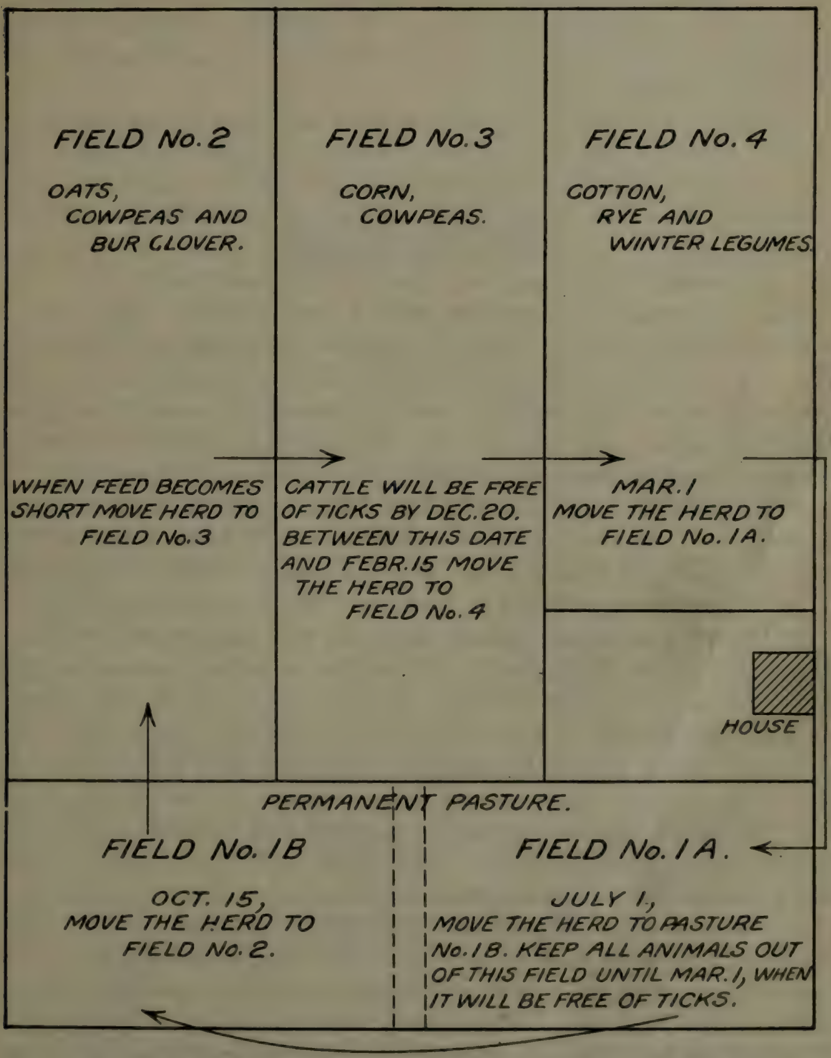

FIELD No. 2
OATS, COWPEAS AND BUR CLOVER.
FIELD No. 3
CORN, COWPEAS.
FIELD No. 4
COTTON, RYE AND WINTER LEGUMES.
WHEN FEED BECOMES SHORT MOVE HERD TO FIELD No. 3
CATTLE WILL BE FREE OF TICKS BY DEC. 20. BETWEEN THIS DATE AND FEBR. 15 MOVE THE HERD TO FIELD No. 4
MAR. 1 MOVE THE HERD TO FIELD No. 1A.
HOUSE
PERMANENT PASTURE.
FIELD No. 1B
OCT. 15, MOVE THE HERD TO FIELD No. 2.
FIELD No. 1A.
JULY 1, MOVE THE HERD TO PASTURE No. 1B. KEEP ALL ANIMALS OUT OF THIS FIELD UNTIL MAR. 1, WHEN IT WILL BE FREE OF TICKS.

FIG. 12.—Plan for freeing cattle and pastures from ticks by rotation, requiring eight months.

Plan requiring eight months.—The plan indicated in figure 12 is begun 15 days later than the preceding one and requires eight months for its completion. The pasture is divided as before. The herd is moved July 1 from field No. 1A to No. 1B, and on October 15 is moved from there to field No. 2. The herd may be continued on fields Nos. 2 and 3 until February 15 in any way found most convenient, since there is no danger of young ticks hatching during that time. The herd is moved not later than February 15 to field No. 4. All the ticks on the cattle will have dropped by December 20, consequently the herd may be moved to field No. 4 as early as that date, if found desirable.

By March 1 the original pasture is free and the cattle are returned there. Field No. 1B will be free of ticks by August 1, at which time the double fence separating the two parts of the pasture may be removed. The rest of the farm will not be certainly free of ticks until September 1. The drainage in general should be from field No. 1A toward No. 1B, and from field No. 4 toward field No. 2.

Plan requiring four months, with a new pasture.—The plan of rotation represented in figure 13 involves changing the location of the pasture. The oat field (field No. 4) after the grain has been harvested is reserved for this purpose. It should be sown in cowpeas, Bermuda grass, and bur clover. The herd is moved October 15 from the original pasture, field No. 1, to field No. 2, where it may be kept for a month or two, or until the feed becomes short, then moved to field No. 3, where it is kept until February 15, when it is moved to the new pasture, field No. 4. The old pasture may be planted in oats. The drainage should be from field No. 4 toward field No. 2.

The feed-lot or soiling method, requiring four and one-half months.—In the plan given in figure 14, the feed-lot or soiling method is made use of to free the cattle of ticks. In the spring field No. 3B, located near the farmyard, is sown in corn for a soiling crop. The area devoted to corn should be sufficient to supply feed for the herd for five or six weeks. Field No. 3A, after the oats are harvested, should be sown in sorghum and cowpeas or millet and cowpeas, and should be large enough to furnish feed for the herd until November 1. These fields should not have had cattle on them for at least 10 months.

Previous to June 15 three lots, each large enough to accommodate the herd, are fenced off in field No. 3B. These lots should not be located on a stream, and the drainage should be from field No. 3A toward field No. 3B. There should be a space of 15 feet or more between the lots. On June 15 the herd is moved to lot No. 1, and afterwards to lots Nos. 2 and 3 at intervals of 20 days. After the cattle have spent the required time in lots Nos. 1 and 2, if it is found, after a careful examination made by some one familiar with such work, that the cattle are free of ticks, they may be turned directly into field No. 3A. If they are not free they should be placed in lot No. 3 until they are free, or, if this can not be determined with certainty, until 15 or 20 days more have elapsed, which will be much longer than necessary for all ticks to drop during July and August.

If desirable, the corn in each lot may be cut and removed before the cattle are placed in it. As soon as possible after the cattle are removed from a lot the female ticks and the eggs present on the ground should be plowed under and the ground along the fence sprayed with crude petroleum or some other disinfectant to prevent any seed ticks which may hatch from getting beyond the area of the lot. Another

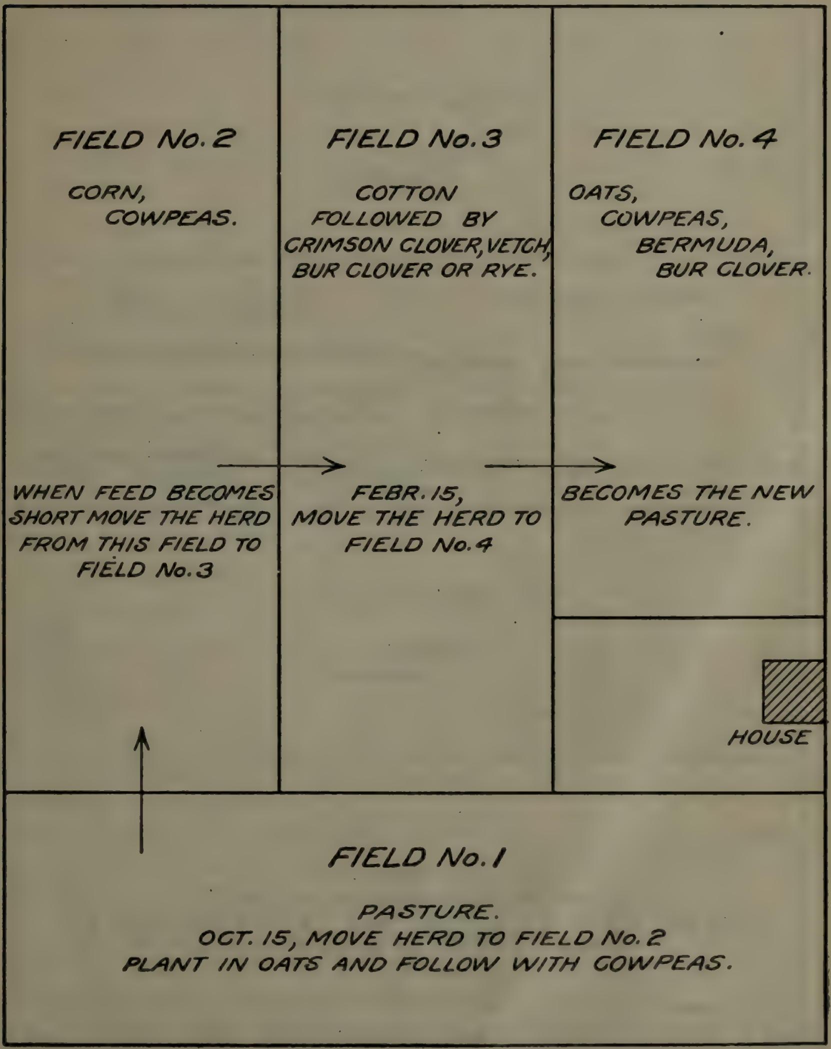

FIELD No. 2
CORN, COWPEAS.
WHEN FEED BECOMES SHORT MOVE THE HERD FROM THIS FIELD TO FIELD No. 3
FIELD No. 3
COTTON FOLLOWED BY CRIMSON CLOVER, VETCH, BUR CLOVER OR RYE.
FEBR. 15, MOVE THE HERD TO FIELD No. 4
FIELD No. 4
OATS, COWPEAS, BERMUDA, BUR CLOVER.
BECOMES THE NEW PASTURE.
HOUSE
FIELD No. 1
PASTURE.
OCT. 15, MOVE HERD TO FIELD No. 2
PLANT IN OATS AND FOLLOW WITH COWPEAS.

FIG. 13.—Plan for freeing cattle and pastures from ticks by rotation, requiring four months, with a new pasture.

valuable precaution will be to use for feed, as far as possible, the corn opposite or in advance of the lot in which the cattle are located, since this is less likely to harbor seed ticks.

The pasture will be free of ticks by November 1, and the cattle may then be returned there if desired. The herd may, however, be continued on field No. 3A as long after that date as the forage lasts, or, in case of a shortage of feed previous to November 1, it may be moved to either field No. 2 or 4, provided one of these is ready for pasturage. These fields may be used for fall and winter pasturage in any way that may be found desirable.

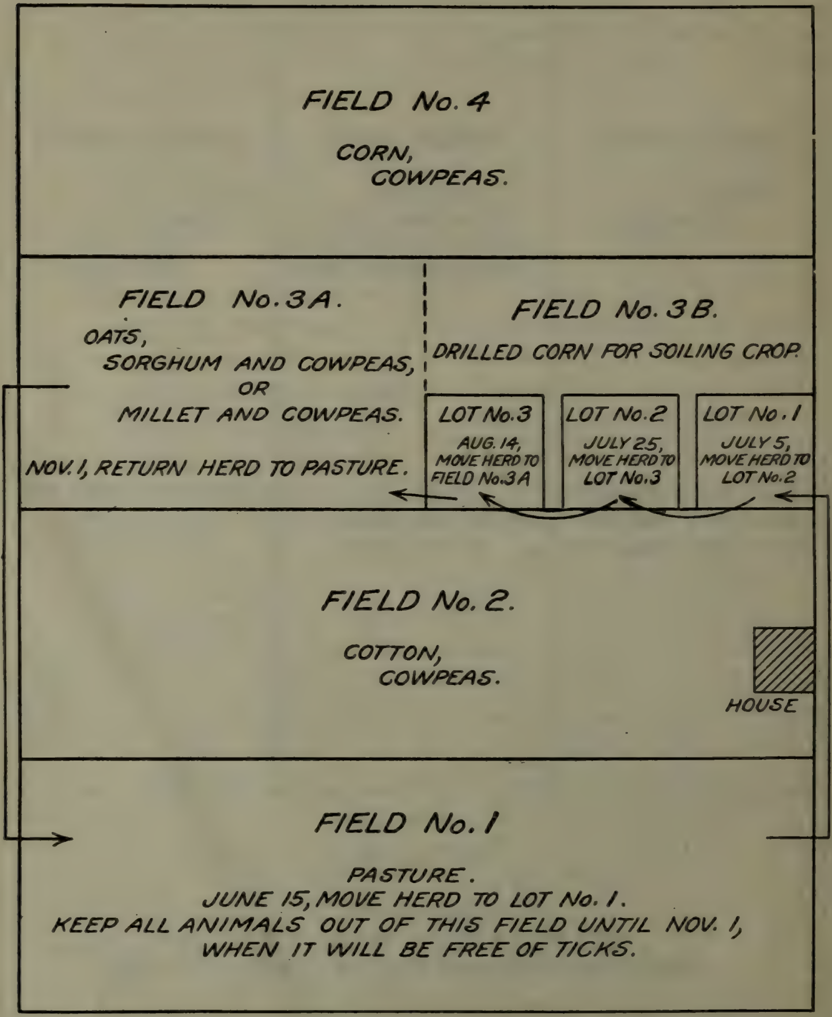

FIELD No. 4
CORN,
COWPEAS.
FIELD No. 3A.
OATS,
SORGHUM AND COWPEAS,
OR
MILLET AND COWPEAS.
NOV. 1, RETURN HERD TO PASTURE.
FIELD No. 3B.
DRILLED CORN FOR SOILING CROP.
LOT No. 3
AUG. 14, MOVE HERD TO FIELD No. 3A
LOT No. 2
JULY 25, MOVE HERD TO LOT No. 3
LOT No. 1
JULY 5, MOVE HERD TO LOT No. 2
FIELD No. 2.
COTTON,
COWPEAS.
HOUSE
FIELD No. 1
PASTURE.
JUNE 15, MOVE HERD TO LOT No. 1.
KEEP ALL ANIMALS OUT OF THIS FIELD UNTIL NOV. 1, WHEN IT WILL BE FREE OF TICKS.

FIG. 14.—Plan for freeing cattle and pastures from ticks by rotation; feed-lot or soiling method.

DIPPING, SPRAYING, AND HAND DRESSING.

Ticks upon cattle may be destroyed by using various tick-destroying agents such as oils and arsenic. These may be applied in three ways, namely, by hand, by the use of spray pumps, and by means of the dipping vat.

Hand application is practicable only when a few animals are to be treated. The substances of value in this method are a mixture of lard and kerosene, cottonseed oil, or a half-and-half mixture of cottonseed oil and kerosene; and finally, crude petroleum, which in general has proved the most effective, although it has some drawbacks, chief of which are the difficulty of obtaining oil of the proper quality, its bulk, which makes its transportation costly, and the liability of injury to cattle when the treatment is applied in hot weather. Any of these preparations may be applied with a mop or a good-sized paint brush, but unless great pains are taken this method of treatment is not thorough, and even at the best some portions of the body where ticks may be located will be missed. This method of application should be resorted to only when for some reason other methods would be found impracticable.

Spraying is adapted for small-sized herds. The arsenical mixture and crude petroleum or emulsions of the same may be applied by means of an ordinary pail spraying pump (fig. 15). There are also pumps on the market designed for making a temporary mechanical mixture of oil and water. Cottonseed oil, or cottonseed oil and kerosene in a half-and-half mixture, or crude petroleum, may be used in these pumps, and a 20 per cent mixture of any one of these will kill most of the ticks. A large spraying machine which is now on the market and which has met with considerable favor in the treatment of large herds of cattle for mange is equally adapted to the application of remedies for ticks, but on account of its expense is not likely to come into general use.

The dipping vat on the whole is the best and cheapest means of applying remedies when large herds are to be treated. The great advantage of dipping over spraying or hand treatment lies in the fact that the thoroughness of the treatment under all conditions is practically assured, not being dependent to any degree on the care exercised by those in charge of the work. The substances usually used in dipping vats are crude petroleum and arsenical dips. Crude petroleum is no longer used to any great extent, and has been replaced by arsenical dips, which have proved more satisfactory in every respect.

CRUDE PETROLEUM.

Various kinds of crude petroleum have been used with more or less success in destroying ticks. The heavier varieties of oil are very injurious to cattle. On the other hand, the very light oils are so volatile that their effects last but a short time, thus rendering them less efficient. The petroleum known as Beaumont oil, obtained from Texas wells, has given the best results. The best grade of this oil to use is one that has a specific gravity ranging from 22½° to 24½° Beaumé, containing 1¼ to 1½ per cent of sulphur, and 40 per cent of the bulk of which boils between 200° and 300° C. The oil may be applied by hand or by employing a spray pump or a dipping vat.

Animals that have been dipped in crude oil, especially during warm weather, should not be driven any great distance immediately afterwards, and should be provided with shade and an abundance of water. Unless these precautions are observed serious injury and losses may result.

Emulsions of crude petroleum.—Instead of plain crude petroleum an emulsion of crude petroleum, preferably Beaumont crude petroleum, may be used. The use of the emulsion makes the treatment less expensive than when the oil alone is used. The emulsion is not so injurious to the cattle and is almost if not quite as effective as the oil alone. The formula for preparing an emulsion of crude petroleum is as follows:

Hard soap	pound..	1
Soft water	gallon..	1
Beaumont crude petroleum	gallons..	4

making 5 gallons of 80 per cent stock emulsion.

When a greater quantity of stock emulsion is desired each of the quantities in the above formula should be multiplied by such a number as to furnish the required amount. For example, if it should be convenient to mix 10 gallons at one time, the quantities would have to be multiplied by 2, and if 15 gallons were desired, they would have to be multiplied by 3, and so on.

In preparing the emulsion the soap should be shaved up and placed in a kettle or caldron containing the required amount of water. The water should be brought to a boil and stirred until the soap is entirely dissolved. Enough water should be added to make up for the loss by evaporation during this process. The soap solution and the required amount of oil are then placed in a barrel or some other convenient receptacle and mixed. The mixing may be effected by the use of a spray pump, pumping the mixture through and through the pump until the emulsion is formed. A convenient and time-saving method is to do the mixing in a barrel by first pouring in one part of hot soap solution and then four parts of crude petroleum and repeating this until the barrel is filled. The oil should be poured in with as much force as possible and the mixture stirred constantly with a long paddle until the oil is completely emulsified. The mixing is facilitated also by dipping up the mixture and pouring it back with a pail.

If made properly this stock emulsion is permanent and will keep indefinitely.

To prepare the stock emulsion for use it is diluted with water to a 20 or 25 per cent emulsion. In order to obtain a 20 per cent emulsion of oil it is necessary to use one part of the stock emulsion to three parts of water, and for a 25 per cent emulsion one part of stock emulsion to two and one-fifth parts of water. The stock emulsion is permanent, but the diluted emulsion does not remain uniformly mixed, so that if allowed to stand it should be thoroughly mixed by stirring before using. Only rain or soft water should be used for diluting, and if this is not available the water should be "softened" by adding a sufficient amount of concentrated lye, sal soda, or washing powder. Care should be observed in this process not to use an excess of these preparations.

ARSENICAL DIPS.

Arsenical dips as agents for destroying cattle ticks have come into much favor during the past few years. This has been due to their efficacy, cheapness, the ease with which they are prepared, and the comparatively slight injury they cause to cattle when properly prepared and used. Homemade dips are the ones most commonly used and are quite satisfactory in every way when ordinary care is used in their preparation. Recently there has been placed on the market a proprietary concentrated arsenical dip which has given good results. This dip is prepared for use by diluting it with cold water in the proportions of 1 to 100. The only advantage in such a dip is that comparatively little time is required in preparing the bath, but this advantage is largely counterbalanced by the fact that it is more expensive than a homemade dip.

The formula most commonly used in making an arsenical dip is the following:

Sodium carbonate (sal soda)	pounds..	24
Arsenic trioxid (white arsenic)	do....	8
Pine tar	gallon..	1

Water sufficient to make 500 gallons.

If for any reason a stronger dip is desired, 25 pounds of sodium carbonate and 10 pounds of arsenic trioxid may be used in place of the amounts given in the above formula. The stronger dip is required by the regulations of the Bureau of Animal Industry in the dipping of cattle which are to enter interstate commerce from quarantined areas, but for ordinary eradication work when immediate removal of the cattle to tick-free areas is not contemplated it will probably be best to use the weaker solution, and this is especially true during hot weather and when the animals are to be treated every two weeks.

In preparing the dip a large caldron or galvanized tank is required for heating the water in which to dissolve the chemicals. Twenty-five gallons of water should be placed in the caldron or tank and brought to a boil. The amount of sodium carbonate indicated in the formula is then added and dissolved by stirring. When this is accomplished, the required amount of arsenic is added and dissolved in a similar manner. The fire is then drawn, and the solution permitted to cool to 140° F., or this process may be hastened by the addition of cold water. The pine tar is then added slowly in a thin stream and thoroughly mixed with the solution by constant stirring. This solution should be diluted at once to 500 gallons.

If a large enough caldron or tank is available for preparing the dip a greater quantity of solution may be prepared at one time, always, of course, in the same proportions as the above. In this way the time required in preparing the amount of solution necessary to fill a vat is reduced considerably. In case it is necessary to use a smaller container, say of about the capacity of 15 gallons, only half the amount of solution indicated should be prepared at one time, the quantities of ingredients used being half those in the formula. This, however, will require so much time in preparing the amount of solution necessary to fill a vat that when possible it is advisable to provide a larger vessel for dissolving the chemicals.

The caldron or tank and utensils used in preparing the dip should be kept free from grease or oil, as small quantities of these may envelop particles of arsenic and prevent or hinder the solution of the arsenic. It should also be borne in mind that when hard water is used in the preparation of the dip the dissolving of the sodium carbonate (sal soda) in the boiling water results in the formation of a fine white or gray insoluble powder or precipitate of lime salts which may be taken for undissolved arsenic, and thus lead to the belief that all of the arsenic has not gone into solution.

The arsenical solution when prepared according to the above method should be diluted as soon as the pine tar has been added, in order that the tar may become properly emulsified. In the concentrated solution the tar tends to separate out, especially when the solution becomes cold, and collect in a layer at the bottom of the container. Even when the plan of immediately diluting the solution is followed a satisfactory emulsion is not always obtained, and some of the tar may separate and go to the bottom of the vat.

If, however, the acids present in the tar are neutralized by the use of concentrated lye a good emulsion of the tar in the diluted dip may be obtained.[1] The neutralization is effected by dissolving 1 pound of concentrated lye in a quart of water for every gallon of tar to be used and adding this solution to the tar, stirring thoroughly. When the acids of the tar have been properly neutralized the resulting mixture should be a bright, thick fluid of a dark-brown color. Whether the acids have been neutralized or not may be determined by taking a small quantity of the tar on the blade of a pocket knife or on a sliver of wood and stirring it in a glass of water. If the acids have been neutralized the tar will mix uniformly with the water; whereas, if they have not been neutralized, the tar will float about in the water in the form of various-sized globules that will settle to the bottom when the agitation of the water ceases. For all ordinary grades of tar one pound of lye to the gallon will be ample to effect neutralization, but if on testing it is found that this amount has not been sufficient, it will be necessary to add more lye solution, about a pint at a time for each gallon, until the test shows that the acids have been neutralized. The neutralized tar should be added to the diluted arsenical dip and not to the concentrated solution with which it will not mix satisfactorily. When the neutralized tar is used the vat should be filled with diluted arsenic-soda solution prepared in the usual way. The required amount of neutralized tar, diluted with two to three times its volume of water, should then be added to the solution in the vat and thoroughly mixed with the same by stirring.

---

[1] This method for emulsifying the tar has been suggested by the Biochemic Division of the Bureau of Animal Industry.

Before filling a vat the capacity at the depth to which it is necessary to fill it for dipping, if not known, should be calculated, and for future convenience the water line should be plainly marked at some point on the wall of the vat. Unless this is done it will be necessary either to calculate the amount of water in the vat each time it is filled or measure it as it is placed in the vat, both of which procedures will consume considerable unnecessary time. The most convenient way to get the water into the vat is to conduct it through pipes, either directly from a pump or from an elevated tank used for storing water for farm purposes. Frequently, however, it is not possible to bring the water to the vat through pipes, and it becomes necessary to resort to the laborious process of hauling it in barrels on wagons or sleds.

In case the pine tar is added to the concentrated solution when it is made, in which case, as already stated, it is necessary to dilute the solution at once, the vat should be partly filled with water and then the arsenical solution added as it is made. For example, if the vat holds 2,000 gallons, about 1,500 gallons of water should be placed in the vat, then four times the amount of solution for making 500 gallons of dip should be prepared and mixed with the water, after which the vat should be filled to the 2,000-gallon mark. Within certain limits it is immaterial just how much water is added at first, provided, of course, ample allowance is made for the volume of the concentrated dip so that when it is added the dip line will not come above the mark to which the vat is to be filled.

The capacity of the vat planned in this bulletin, at a depth of 5 feet 3 inches, is 1,470 gallons. In order to fill it to that depth with dip it will be necessary to prepare two batches of concentrated dip, each containing the ingredients necessary for making 500 gallons of diluted dip, and a third batch containing 7 pounds 9 ounces of arsenic and 22 pounds 3 ounces of sodium carbonate in case 8 pounds of arsenic are being used to the 500 gallons, or 9 pounds 7 ounces of arsenic and 22 pounds 8 ounces of sodium carbonate in case 10 pounds of arsenic are being used to the 500 gallons.

A stock arsenical solution is found convenient for replenishing the dip in a vat when it has gotten too low for dipping and in cases in which spraying is regularly done on a farm, and also in eradication work when it is necessary for inspectors to carry a supply of arsenical dip from farm to farm for use in spraying. In the latter case it is especially desirable that the stock solution be of a high concentration because of the limited amount of space available for carrying the required amount of dip. A stock solution in which the ingredients for 500 gallons of dip are dissolved in 25 gallons of water will probably meet the requirements in most instances. In making up the stock solution the arsenic and sal soda for 500 gallons should be dissolved in the usual manner in 25 gallons of water. The tar should not be added to the stock solution. Special care should be observed to see that the solution after boiling and cooking measures 25 gallons, and any deficiency due to evaporation during boiling should be made up by adding cold water. Nineteen parts of water to one part of this solution will give the proper dilution. The tar, neutralized in the manner already described, should be mixed with the solution after it has been diluted, in the proportion of about half a pint for every 30 gallons of diluted dip.

In diluting stock solutions great care should always be used in measuring the amount of solution and water used. A small error in measuring the amount of stock solution required is likely to cause a considerable variation in the arsenic content of the dip, especially if the quantity prepared is small. If the variation happens to be in the direction of too low a percentage of arsenic, the treatment may not prove effective, whereas if it happens to be in the other direction cattle that are treated may be injured or even killed. Care is especially necessary in the case of a certain highly concentrated proprietary dip to be used at a dilution of 1 to 100. In using this great care should be observed in measuring the amount required, and the dilution recommended of 1 to 100 should be strictly followed.

The arsenical dip may be left in the vat and used repeatedly, replenishing it with the proper quantities of water and stock solution when necessary. When, however, the dip becomes filthy through the addition of manure and dirt carried in by the cattle, the vat should be emptied, cleaned, and filled with fresh fluid. The frequency with which this should be done must be left to the owner, as the condition of the dip at any period after it has been made depends on a variety of conditions, such as the number of cattle dipped, the frequency of the dippings, etc. Even though the dip may not become very filthy, its efficacy decreases somewhat on standing, owing to gradual oxidation of the arsenic. It is therefore advisable to recharge the vat at intervals irrespective of the condition of the dip as to cleanliness.[1]

In order that dipping in arsenic may be both efficacious in destroying ticks and also harmless to the cattle at all times, it is of the highest importance that the dip be of the proper strength when made and that it be maintained as far as practicable at that strength. Due care in making the dip and in calculating the capacity of the vat will of course assure the correct initial strength of the dip. Providing the vat with a waterproof cover will do much to maintain the dip at its proper strength by preventing on the one hand concentration by evaporation and on the other hand dilution by rains. A cover will also reduce the risk of cattle being poisoned during the intervals between dippings, especially when the vat is not protected by a fence. During rains the water from the draining pen or chute should not be permitted to run into the vat and dilute the dip.

At the conclusion of each dipping, especially if the vat is without a cover, it is well to mark the position of the surface of the dip on the side of the vat in order to determine at the next dipping whether there has been a change in the level of the dip. If the surface of the dip has fallen and it is known that the vat does not leak, there has been a loss of water by evaporation and consequently an increase in the strength of the dip. In order to bring the dip down to its former strength water should be run into the vat until the dip surface reaches the mark made at the last dipping. If the fall has been due to the vat leaking, the strength of the dip has not been altered and consequently water alone should not be added. If the dip surface has been raised by rain the amount of water added in this way should be determined by calculation, and for every 19 of water 1 gallon of the stock solution previously mentioned should be used.

Precautions in the use of arsenic.—Because of the fact that arsenic is a poison great pains should be taken in caring for it after it is purchased from the druggist, in order that persons and animals may not be accidentally poisoned. The dip at the time it is being made and also after it is diluted should be handled and protected as a poison. Unless such precautions are observed accidents are certain to occur. When, however, arsenic is handled with the proper care there is no more danger in its use on the farm than in the use of a number of other poisons that are commonly and regularly employed by farmers for destroying insect pests of plants and obnoxious rodents.

---

[1] Mr. R. M. Chapin, of the Biochemic Division, has invented a portable test case for testing arsenical dips in the field, which has been shown to be a practical success after extensive field tests. With this device it is now possible to ascertain quickly the strength of the dip in a vat and thus determine when the vat should be recharged. It is the intention of the bureau to place test outfits in the hands of its men engaged in tick eradication.

Persons using the dip, especially with the spray pump, should not subject their hands and other portions of the body, by permitting their clothing to become wet, to the action of the dip any more than is necessary, and it is well to wash the hands well after each spraying, especially when they are frequently subjected to the dip. At the time the dip is being prepared care should be observed not to inhale the vapor arising from the caldron or kettle, and during spraying the same precaution should be exercised against the inhalation of the spray.

In making the dip, weights and measures should not be guessed at, and the arsenic, especially, should be weighed with the greatest care.

Cattle should always be watered a short time before they are dipped. After they emerge from the vat they should be kept on a draining floor until the dip ceases to run from their bodies; then they should be placed in a yard free of vegetation until they are entirely dry. If cattle are allowed to drain in places where pools of dip collect from which they may drink, or are turned at once on the pasture, where the dip will run from their bodies on the grass and other vegetation, serious losses are liable to result. Crowding the animals before they are dry should also be avoided, and they should not be driven any considerable distance within a week after dipping, especially in hot weather. If many repeated treatments are given, the cattle should not be treated oftener than every two weeks.

In addition to properly protecting vats containing arsenical dip when not in use another precaution must be observed when vats are to be emptied for cleaning. The dip should not be poured or allowed to flow on land and vegetation to which cattle or other animals have access. The best plan is to run the dip into a pit properly protected by fences. The dip should also not be deposited where it may be carried by seepage into wells or springs which supply water used on the farm.

Dalrymple and Kerr[1] have suggested a method of rendering the arsenical dip harmless by the use of air-slaked lime and copperas (ferrous sulphate). This method should not, however, be used alone, but rather as a precautionary measure supplementary to the plan suggested above for disposing of the dip.

---

[1] W. H. Dalrymple and A. P. Kerr, Bulletin 132, Louisiana Agricultural Experiment Station.

The process consists in using 6 pounds each of air-slaked lime and copperas to each 100 gallons of dip to be treated. The required amount of lime is first added to the dip and thoroughly mixed with it by stirring. After this treatment the dip should be permitted to stand for at least an hour. The copperas should then be dissolved in hot water and the solution while still hot should be added slowly to the dip and well mixed with the same by stirring. The dip should then be permitted to stand for at least 12 hours, after which it may be removed from the vat and disposed of in the way suggested.[1]

PROCEDURE IN DIPPING AND SPRAYING.

Whether dipping or spraying is employed in eradicating ticks from a farm, the method of procedure is the same. In undertaking eradication, all the cattle, and also the horses and mules in case they harbor ticks, are treated regularly every two or three weeks, during the part of the year that the temperature is favorable to treatment, until the ticks have disappeared from the farm. The purpose of the treatment is to destroy all ticks that get on the animals before they have had a chance to mature and drop, and thus prevent them from reinfesting the pasture and other portions of the farm. If the treatment used were absolutely effective in destroying each and every tick on the animals treated there would be no renewal of the infestation on the farm after the treatment is begun, and the cattle would act simply as collectors of ticks which would be destroyed regularly by the treatment applied every two or three weeks. It is likely, however, that in most instances, either because of the lack of efficacy of the dip or imperfect application, or both, some ticks escape treatment and reproduce on the pasture, resulting in prolonging the time that would otherwise be required for eradication.

If ticks apparently disappear from the cattle after they have been under treatment for some time, the dipping or spraying should not be discontinued until it has been determined by a number of careful hand inspections that the cattle are free of ticks. If ticks continue on cattle until cold weather and then finally disappear it should be borne in mind that in all probability eradication has not been accomplished and that there may be engorged females, unhatched eggs, and inactive seed ticks on the farm, and that even if the cattle should remain free of ticks during the winter they may become reinfested the following spring. In any case in which ticks disappear from the cattle and treatment is discontinued the cattle should be watched with the greatest care for ticks until ample time has elapsed to leave no doubt that the farm is free of ticks.

---

[1] The Biochemic Division is at present investigating the process proposed by Dalrymple, together with other possible processes for attaining the same end. The essential part in the process is played by caustic lime which, when present in excess, precipitates all but practically inappreciable traces of the arsenic as insoluble calcium arsenite. It is therefore desirable to use quicklime in place of the air-slaked lime recommended by Dalrymple, slaking it with water in the usual manner before adding to the dip, while the addition of ferrous sulphate appears to be unnecessary.

After a farm has been freed of ticks precautions should be observed to prevent ticks from being reintroduced on the place. In case it becomes necessary to bring cattle to the farm from ticky farms they should be completely freed of ticks before being brought on the place; or, if this is not possible, a quarantine lot or pen should be set aside on the farm to be used exclusively for ticky cattle, where such cattle may be kept and entirely freed of ticks before being placed with the other cattle. Such cattle may be freed of ticks by dipping them twice at an interval of 7 to 10 days in an arsenical dip containing 10 pounds of arsenic to the 500 gallons. After the second dipping the cattle should not be placed in the quarantine pen, but placed in a tick-free lot, where they may be observed for a time to see that the treatment has been entirely effective, after which they may be placed with the other cattle, if desired.

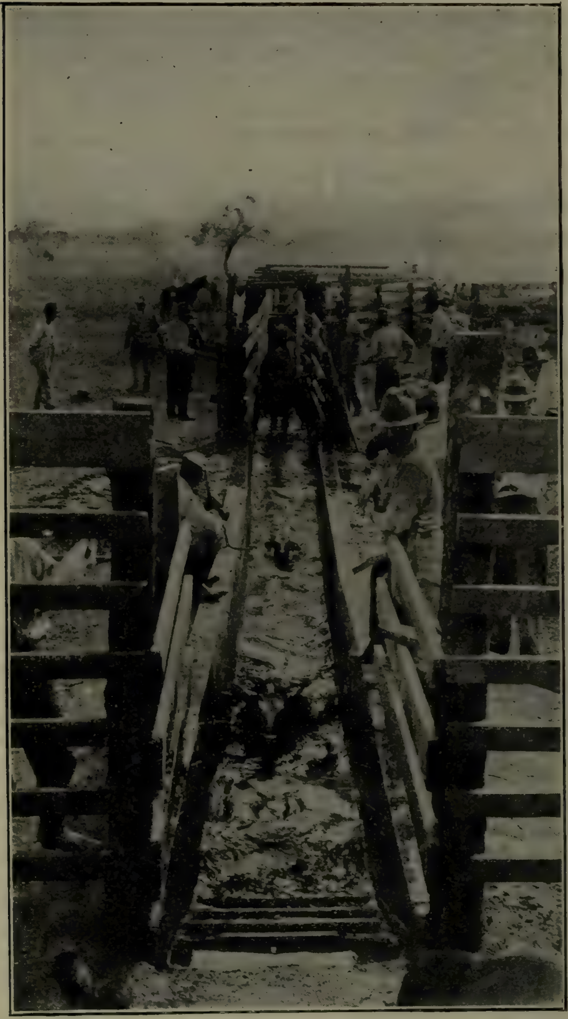


FIG. 15.—Dipping cattle.

In dipping, each animal should be completely submerged in the dip, and to prevent any animals going through the vat without becoming wet all over with the dip a man should be stationed at the middle of the vat with a forked stick to shove those under that may have failed to be completely submerged. (See fig. 15.)

Dipping, as a rule, will be found more satisfactory in every way than spraying. The treatment requires much less time and, as a rule, will be found much more effective. In many cases, however, where the number of cattle on a farm is small, it is not economical to construct a dipping vat. In such cases if there is a sufficient number of cattle within a radius of several miles to warrant the construction of a vat, it will be advisable for the farmers to cooperate in constructing a vat where all of the cattle of the community may be dipped. In case the construction of a community vat is impracticable, it will then be necessary to resort to spraying or hand dressing.

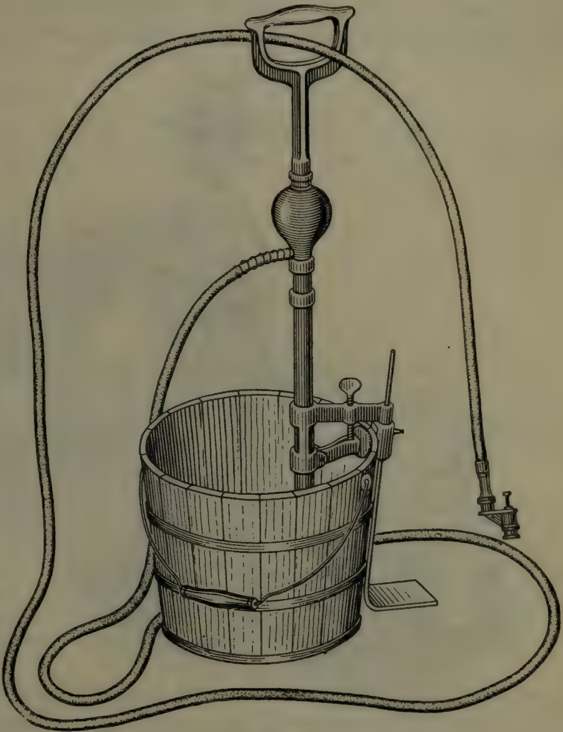


FIG. 16.—Pail spraying pump for small herds.

In spraying animals, a good type of pail spray pump (fig. 16), costing from $5 to $7, will probably be found most satisfactory. It should be provided with about 15 feet of ⅜-inch high-pressure hose and a type of nozzle furnishing a cone-shaped spray of not too wide an angle. A nozzle with a very small aperture should not be used, because the spray produced is too fine to wet properly the hair and skin of the animals without consuming an unnecessary amount of time.

In spraying animals the work should be done with great thoroughness. The animal to be sprayed should be securely tied to a post, or, better still, to one of the posts of a board or rail fence or in a fence corner, where it can not circle about to avoid the treatment. Every portion of the body should be thoroughly treated, special attention being given to the head, dewlap, brisket, inside of elbows, inside of thighs and flanks, the tail, and the depressions at the base of the tail. An animal can not be satisfactorily sprayed unless it is restrained by tying or some other means, and results can not be obtained unless the hair and skin are thoroughly wetted.

In some instances a large oil can with a hole cut in the top (fig. 17) for the admission of the spray pump has been used in place of an ordinary bucket. Such a can has the advantage that animals can not drink from it, and if it is permitted to stand unguarded, as is likely to occur at any time during the operation of spraying a herd, there is no danger of animals being poisoned by drinking the dip.

A convenient arrangement in handling the nozzle during spraying is to tie it loosely by its base to the end of a stick about 3 feet long (fig. 18). By moving the stick rapidly back and forth the spray may be caused to vibrate, and by various manipulations of the hose in relation to the stick the spray may be readily directed in any direction.

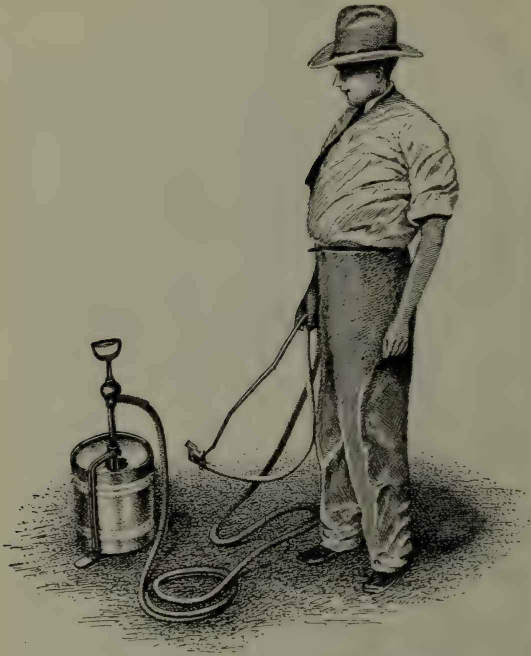


FIG. 17.—Oil can used with spraying pump.

RULE FOR CALCULATING THE CAPACITY OF A DIPPING VAT.

The following rule has been adapted by Dr. B. H. Ransom from a mathematical formula for calculating the volume of a prismoid:

(1) Reduce all dimensions to the same denomination, feet or inches.

(2) Add the length of the bottom of the vat to the length at the water line.

(3) Add the width of the bottom to the width at the water line.

(4) Multiply these sums (2) and (3) together.

(5) Multiply the length of the bottom by the width of the bottom.

(6) Multiply the length at the water line by the width at the water line.

(7) Add together (4), (5), and (6).

(8) Multiply this sum (7) by one-sixth the perpendicular depth from the water line to the bottom, which gives the capacity of the vat in cubic feet or cubic inches.

(9) If the capacity in cubic inches has been obtained, divide (8) by 231; if the capacity in cubic feet has been obtained, divide (8) by 0.1336. In either case the result will be the capacity of the vat in gallons.

This method is mathematically accurate if the vat is set level, but if it is set so that it is slightly lower at one end than at the other, as is usual, the true capacity can not be obtained by this method. If, however, the figures for the width at the water line and the depth are taken from measurements at the middle of the vat the results obtained will vary only very slightly from the actual capacity.

SPECIFICATIONS FOR THE CONSTRUCTION OF A CONCRETE CATTLE-DIPPING VAT.[1]

Site.—The site selected for the location of the vat should be dry and of sufficient size to admit of the construction of the chute, the dripping pen, and at least two additional pens—one for holding the cattle prior to dipping and the other for retaining them after dipping until sufficiently dried.

Excavation.—The excavation should be made 1 foot wider and 1 foot longer than the inside dimensions of the vat and should conform to its shape. The inside dimensions of the vat are shown on the drawings (fig. 19) and are as follows: Length at top of vat, 26 feet; bottom, 12 feet. Width at top, 3 feet; at bottom, 1½ feet. Depth, 6½ feet.

The sides and bottom of the excavation should be firm and solid, as they are to serve for the outside forms in casting the concrete. If it is necessary to do any filling in order to conform to the shape of the vat, the filling should be puddled and thoroughly rammed until solid, because the stability of the concrete depends on the foundation.

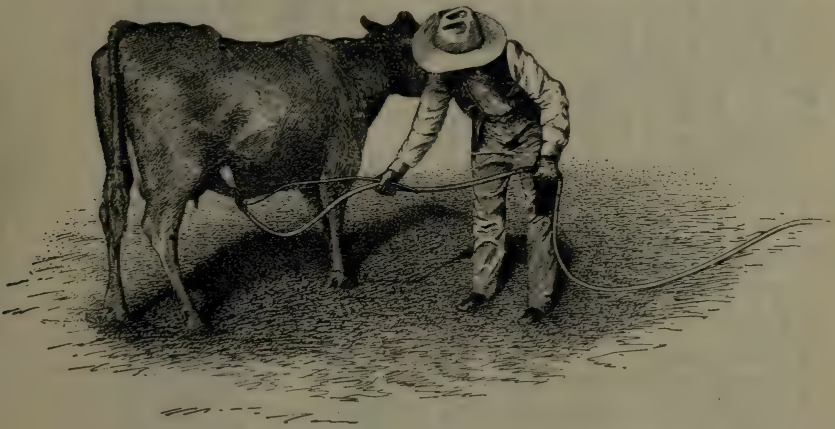


FIG. 18.—Convenient method of holding nozzle in spraying.

Forms.—The wooden forms should be constructed of 1-inch boards and 2 by 4 inch braces, the boards being nailed to the outside face of the braces, as shown in the drawings. The sides and end walls should be built 8 inches higher than the surface of the ground, which should be level.

Concrete.—The concrete should be made of one part of cement, by measure, two and one-half parts of sand, and five parts of broken rock or gravel. The cement should be of a standard brand of Portland, the sand clean and coarse, and the broken rock from about ¼-inch pieces to not larger than will pass in every direction through a 1-inch ring.

---

[1] Taken from Circular 183, Bureau of Animal Industry.

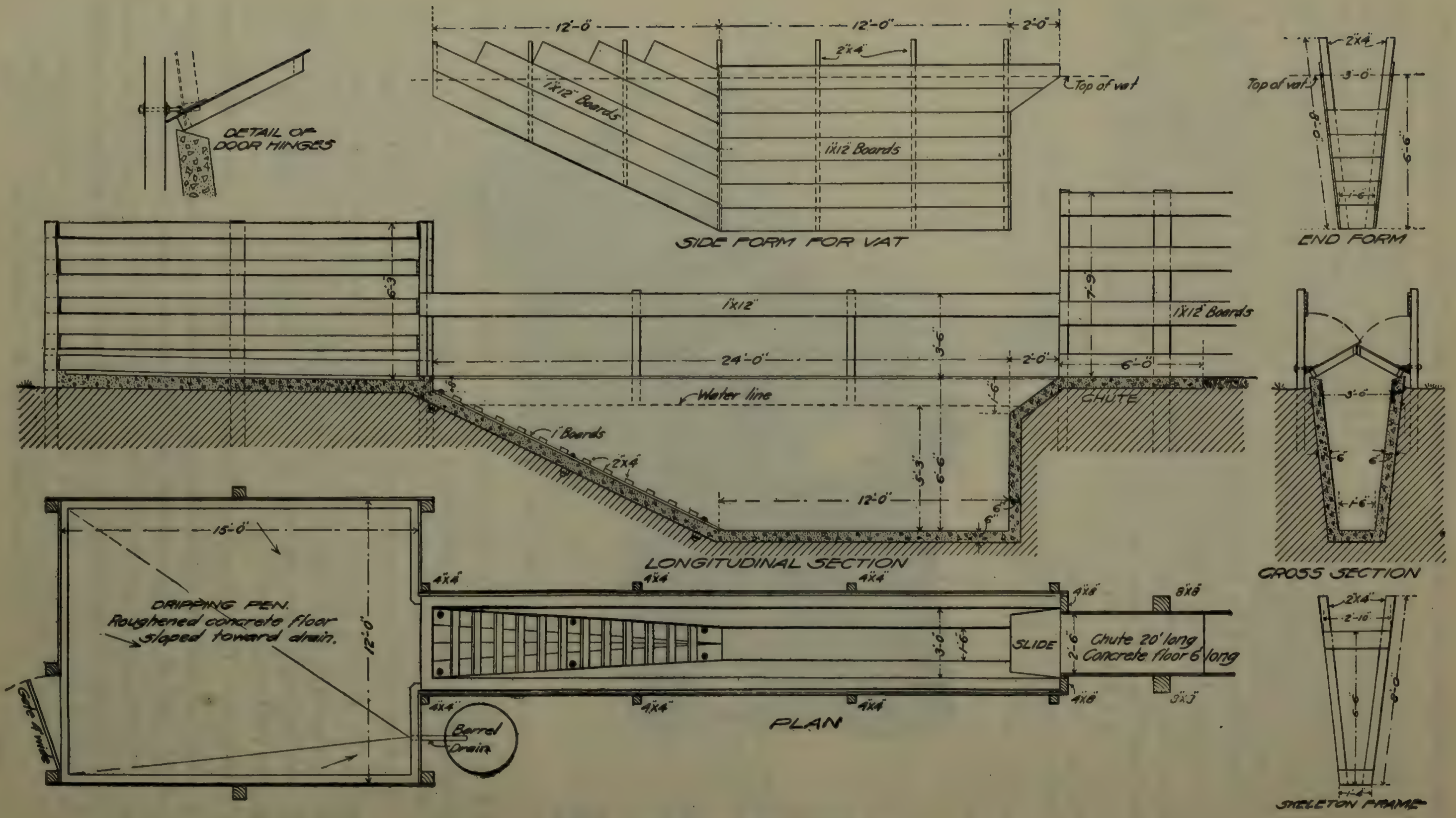


Fig. 19.—Plans for a concrete dipping vat.

Mixing.—The mixing should be done on a tight wooden platform or in a tight box. The sand and stone should be measured in a bottomless box, 2½ feet long by 2 feet wide by 1 foot deep, having a capacity of 5 cubic feet. A convenient size of batch to mix is one consisting of two bags of cement, one measure (5 cubic feet) of sand, and two measures (10 cubic feet) of stone.

The sand is measured out first and the cement emptied on top, after which the two materials are thoroughly mixed together, dry. In the meantime the stone may be measured out and thoroughly drenched with water. The cement-sand mixture is mixed with water and the resulting mortar then combined with the stone. The stone should be shoveled on the mortar, which has been previously spread out in a thin layer. Mixing should continue until the stone is thoroughly coated with mortar, more water being added during the mixing process if necessary.

Laying.—Before laying the concrete the molds should be set and thoroughly braced into place. The side forms may be suspended in the excavation with their lower edges 6 inches from the bottom by means of crosspieces nailed to the uprights and of sufficient length to rest on supports located several feet from the edges of the excavation. The concrete for the bottom and incline is deposited first, this mixture being of a consistency that water will flush to the surface on ramming. The mixtures for the sides and end should be very wet and should be thoroughly puddled into place. The consistency of the concrete for the side walls should be such that it will run off the shovel unless handled quickly.

The laying of the concrete should be done, if possible, in one operation, in order that there may be no joints between the new and old work. If it becomes necessary to lay the concrete on two or more days, the surface on which the new concrete is to be deposited should be washed thoroughly clean and coated with grout of pure Portland cement and water mixed to the consistency of cream. The new concrete should be placed before the grout has set. Extreme care should be taken to prevent dirt from falling in on top of the deposited concrete.

The forms should not be removed until the concrete is set, which in moderate weather will have taken place in about 24 hours. In damp, cold weather at least 48 hours should be allowed before removin the forms. It will be advisable, especially in water-soaked ground, to allow the forms to remain in place for one week before removal.

Finishing coat.—Before applying the surface coat, dampen the walls and floor thoroughly. Cover the entire exposed surface of the floor and walls with a coating one-half inch thick of cement mortar composed of Portland cement 1 part, sand 2 parts. Coating to be floated and troweled to a smooth finish.

Waterproofing.—If the earth around the vat is thoroughly drained the vat may be waterproofed by painting the surface coat, but painting the surface will not give satisfactory results if there is ground water to seep in. The paint may be good hot pine tar, or gas-house tar cut with naphtha or gasoline and applied with a brush, or after the mortar coat has hardened the inside of the vat may be painted with an oil-cement paint made as follows:[1] Mix enough water with Portland cement to make a fairly stiff paste; add to this 5 per cent of heavy petroleum residuum oil based on the weight of the cement, and mix thoroughly until the oil entirely disappears, then add more water and stir until a paint of the consistency of cream is formed. This paint should be applied with a brush and should be well rubbed into the surface. Should the mortar coat be omitted the paint coat should be applied directly to the surface of the concrete.

Exit incline.—As the exit incline is to have a false wooden floor, it will be necessary to embed iron bolts in the concrete, to which the wooden floor may be fastened. Before the concrete incline is laid, embed in the dirt three pieces of 2 by 4-inch scantling, placed at the top, center, and bottom of the incline. The bolts should extend through these pieces and should be placed with the head next to the dirt. The bolts should be long enough to extend through the concrete and the inch boards of the floor, so that the wooden floor may be securely fastened.

Slide.—Cover the slide with a sheet of boiler iron properly fastened to the cement.

Cover.—The cover of the vat consists of two leaves hinged on posts set 3 feet in the ground along each side of the vat. The leaves are 2 feet 6 inches wide, and when open rest against the upper part of the posts to which they are hinged and serve as splash boards. The details of the hinge[2] used and the method of setting it are shown in the drawings. When the leaves are open their lower edges are just above the top of the side walls, which are given a slope inward for the purpose of conducting the dip running from the splash boards back into the vat. Removable doors should be constructed to close the triangular openings left at the ends of the vat when the cover is closed. The hinges may be made by a blacksmith.

Dripping pen.—Construct a dripping pen about 12 by 15 feet at the head of the exit incline. The floor should be of concrete prepared as previously described for the vat and laid in a similar manner.

---

[1] These directions for the oil-cement paint are furnished by the Office of Public Roads of the U. S. Department of Agriculture.

[2] This hinge and the method of setting it for the cover of a dipping vat have been copied from an article by William Taylor Heslop in the Agricultural Journal of the Union of South Africa, Pretoria, vol. 1, No. 1, 1911, pp. 38–43.

The floor should be pitched toward a corner of the pen, where a pipe should be laid in the floor to carry the drippings into a barrel sunk in the ground. The drippings thus caught may be returned to the vat after settling. The floor should be roughened to prevent the cattle from slipping.

Chute.—The chute leading to the vat should be built 30 inches wide and 20 feet long, and the receiving and retaining pens should be of a size to take care of the animals to be dipped.

Bill of materials for vat, dripping pen, and chute.

LUMBER FOR FORMS.

8 pieces 1 by 12 inches by 14 feet long.
13 pieces 1 by 12 inches by 12 feet long.
2 pieces 1 by 12 inches by 9 feet long.
2 pieces 1 by 12 inches by 6 feet long.
2 pieces 1 by 12 inches by 4 feet long.
8 pieces 2 by 4 inches by 8 feet long.
2 pieces 2 by 4 inches by 7 feet long.
2 pieces 2 by 4 inches by 6 feet long.
2 pieces 2 by 4 inches by 4 feet long.
2 pieces 2 by 4 inches by 2 feet long.
7 pieces 1 by 6 inches by 12 feet long for crosspieces for inside of forms.

LUMBER FOR DRIPPING PEN.

7 pieces 6 by 6 inches by 10 feet long for posts.
10 pieces 1 by 8 inches by 16 feet long for side rails of pen.
5 pieces 1 by 8 inches by 12 feet long for side rails of pen.
5 pieces 1 by 8 inches by 8 feet long for side rails of pen.

The covers can be made from the lumber used in making the forms, and the lumber for the exit incline can be gotten in the same way.

The 4 by 4-inch posts to which the cover is hinged may be made from 2 by 4 stuff by spiking together.

End form to be made solid.

HARDWARE AND IRONWORK.

Six bolts, ½ by 10 inches, with nuts and washers, for false floor of incline.

One sheet of ¼-inch boiler iron cut to shape of slide; plate bored and countersunk for four screws.

Four pairs hinges for covers.

Three heavy T hinges and screws for gate of dripping pen.

One heavy iron bolt to fasten gate.

CONCRETE.

VAT.

Cement, 10½ barrels (42 bags).
Sand, 3¾ cubic yards.
Stone, 6¼ cubic yards.

DRIPPING PEN AND CHUTE.

Cement, 5½ barrels (22 bags).
Sand, 1¾ cubic yards.
Stone, 3½ cubic yards.

A 26-foot vat has been used extensively for eradication purposes with satisfactory results. However, if it is desired to lengthen the body of the vat on account of large numbers of cattle to be treated, or to make it conform to the bureau's requirements for the treatment of cattle for movement as noninfectious, there should be added to the amount of concrete material for each linear or running foot, cement, 0.37 barrel; sand, 0.12 yard; stone, 0.24 yard.

By some a dripping chute is regarded more satisfactory than a dripping pen. One of the advantages that it has is that the cattle are held in line in the order in which they have been dipped, thus making it possible to remove one or more of them at a time as soon as they have drained sufficiently in order to make room for others. In using the dripping pen this is not practicable, and it is necessary to wait until the last animal dipped has drained sufficiently and then remove them all together.

In case it is desired to construct a dripping chute it should be located at the head of the exit incline in line with the vat. It should be about 36 inches wide. The length will depend on the number of cattle it is desired to accommodate at one time, it being necessary to allow 4 to 5 feet for each. A length of from 20 to 40 feet is considered a convenient size for small herds. The floor should be made of concrete and sloped toward the vat. The dip should not be permitted to run directly into the vat, but should be collected in a barrel to settle, as shown in the case of the dripping pen. The floor at the sides should be raised about 2 inches in the form of a curb to keep the dip from running off.

1444 Issued June 1, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

June 17, 1912

FARMERS' BULLETIN 499.

Experiment Station Work,

LXIX.

Compiled from the Publications of the Agricultural Experiment Stations.

TOP-DRESSING PASTURES.
MAKING HAY.
A FRESH-AIR BROODER.
ROOSTING CLOSET FOR POULTRY.
EXHIBITION CONTESTS OF DAIRY PRODUCTS.
BLIND STAGGERS OF HORSES.
ADOBE AS A BUILDING MATERIAL.
WHITE AND COLOR WASHES.

MARCH, 1912.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

THE AGRICULTURAL EXPERIMENT STATIONS.

- ALABAMA—
  - College Station: *Auburn;* J. F. Duggar.[1]
  - Canebrake Station: *Uniontown;* L. H. Moore.[1]
  - Tuskegee Station: *Tuskegee Institute;* G. W. Carver.[1]
- ALASKA—*Sitka:* C. C. Georgeson.[2]
- ARIZONA—*Tucson:* R. H. Forbes.[1]
- ARKANSAS—*Fayetteville:* C. F. Adams.[1]
- CALIFORNIA—*Berkeley:* E. J. Wickson.[1]
- COLORADO—*Fort Collins:* C. P. Gillette.[1]
- CONNECTICUT—
  - State Station: *New Haven;* E. H. Jenkins.[1]
  - Storrs Station: *Storrs;* L. A. Clinton.[1]
- DELAWARE—*Newark:* H. Hayward.[1]
- FLORIDA—*Gainesville:* P. H. Rolfs.[1]
- GEORGIA—*Experiment:* Martin V. Calvin.[1]
- GUAM—*Island of Guam:* J. B. Thompson.
- HAWAII—
  - Federal Station: *Honolulu;* E. V. Wilcox.[2]
  - Sugar Planters' Station: *Honolulu;* C. F. Eckart.[1]
- IDAHO—*Moscow:* W. L. Carlyle.[1]
- ILLINOIS—*Urbana:* E. Davenport.[1]
- INDIANA—*La Fayette:* A. Goss.[1]
- IOWA—*Ames:* C. F. Curtiss.[1]
- KANSAS—*Manhattan:* E. H. Webster.[1]
- KENTUCKY—*Lexington:* M. A. Scovell.[1]
- LOUISIANA—
  - State Station: *Baton Rouge;*
  - Sugar Station: *Audubon Park, New Orleans;*
  - North La. Station: *Calhoun;*
  - Rice Station: *Crowley;*
  - W. R. Dodson.[1]
- MAINE—*Orono:* C. D. Woods.[1]
- MARYLAND—*College Park:* H. J. Patterson.[1]
- MASSACHUSETTS—*Amherst:* W. P. Brooks.
- MICHIGAN—*East Lansing:* R. S. Shaw.[1]
- MINNESOTA—*University Farm, St. Paul:* A. F. Woods.[1]
- MISSISSIPPI—*Agricultural College:* E. R. Lloyd.[1]
- MISSOURI—
  - College Station: *Columbia;* F. B. Mumford.[1]
  - Fruit Station: *Mountain Grove;* Paul Evans.[1]
- MONTANA—*Bozeman:* F. B. Linfield.[1]
- NEBRASKA—*Lincoln:* E. A. Burnett.[1]
- NEVADA—*Reno:* G. H. True.[1]
- NEW HAMPSHIRE—*Durham:* J. C. Kendall.[1]
- NEW JERSEY—*New Brunswick:* J. G. Lipman.[1]
- NEW MEXICO—*State College:* Luther Foster.[1]
- NEW YORK—
  - State Station: *Geneva;* W. H. Jordan.[1]
  - Cornell Station: *Ithaca;* L. H. Bailey.[1]
- NORTH CAROLINA—
  - College Station: *West Raleigh;* C. B. Williams.[1]
  - State Station: *Raleigh;* B. W. Kilgore.[1]
- NORTH DAKOTA—*Agricultural College:* J. H. Worst.[1]
- OHIO—*Wooster:* C. E. Thorne.[1]
- OKLAHOMA—*Stillwater:* J. A. Wilson.[1]
- OREGON—*Corvallis:* J. Withycombe.[1]
- PENNSYLVANIA—
  - *State College:* T. F. Hunt.[1]
  - *State College:* Institute of Animal Nutrition, H. P. Armsby.[1]
- PORTO RICO—
  - Federal Station: *Mayaguez;* D. W. May.[2]
  - Sugar Planters' Station: *Rio Piedras;* J. T. Crawley.[1]
- RHODE ISLAND—*Kingston:* H. J. Wheeler.[1]
- SOUTH CAROLINA—*Clemson College:* J. N. Harper.[1]
- SOUTH DAKOTA—*Brookings:* J. W. Wilson.[1]
- TENNESSEE—*Knoxville:* H. A. Morgan.[1]
- TEXAS—*College Station:* B. Youngblood.
- UTAH—*Logan:* E. D. Ball.[1]
- VERMONT—*Burlington:* J. L. Hills.[1]
- VIRGINIA—
  - *Blacksburg:* S. W. Fletcher.[1]
  - *Norfolk:* Truck Station, T. C. Johnson.[1]
- WASHINGTON—*Pullman:* R. W. Thatcher.[1]
- WEST VIRGINIA—*Morgantown:* E. D. Sanderson.[1]
- WISCONSIN—*Madison:* H. L. Russell.[1]
- WYOMING—*Laramie:* H. G. Knight.[1]

---

[1] Director.

[2] Special agent in charge.

EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

CONTENTS OF NO. LXIX.

Page.
Top-dressing pastures 5
Making hay 6
    Cutting the hay 7
    Curing the hay 8
    Storing the hay 9
A fresh-air brooder 10
Roosting closet for poultry 13
Exhibition contests for improving dairy products 15
Blind staggers of horses 19
Adobe as a building material 20
White and color washes 23

ILLUSTRATIONS.

	Page.
Fig. 1. Floor plan of fresh-air brooder	11
2. End elevation of brooder	12
3. Section through middle of brooder	13
4. Brooder installed and ready for operation	14
5. Trimming edge of adobe wall with hay knife	22

EXPERIMENT STATION WORK.[1]

TOP-DRESSING PASTURES.[2]

That certain kinds of run-down pastures may be successfully restored by a proper system of top-dressing has been clearly shown by experiments made by W. P. Brooks at the Massachusetts Experiment Station on one of the typical pastures of the region, a large proportion of which is stated to be producing relatively little feed. In the early spring of 1909, 500 pounds of basic slag and 300 pounds of low-grade sulphate of potash (mixed together just before using) was applied per acre to this pasture.

Before the end of the first season there was a marked difference in the character of the growth upon the fertilized and unfertilized plats. On the former, white clover was found to be coming in, while the grasses showed a much greener color and more vigorous growth.

The pasture in which these plats lay was heavily stocked with milch cows throughout the summer, and it was observed that they grazed upon the top-dressed plats a much larger proportion of the time than on the other portions of the pasture.

In the spring of 1910 the application was repeated, with the result that the effect of the fertilizing was still more marked than in the previous season. As a consequence of the improvement in the character of the forage produced on the top-dressed land, this portion of the pasture was more closely grazed than is considered favorable for the best development. Nevertheless, the improvement in the character of the herbage was very striking, and it is estimated that the top-dressed area produced fully three times the amount of feed yielded by the untreated pasture. It is pointed out that not all pastures can be top-dressed successfully, but in many other cases top-dressing is the only practicable method of improvement.

It is not believed it will be found profitable except in those cases where the turf is mostly free from foreign growths, such as shrubs, bushes, hardhack (spirea), and ferns. If any considerable proportion of the area is occupied by such foreign growths, the first step in improvement should be their removal. * * * When cleared of foreign vegetation a pasture may, in many cases with advantage, be harrowed and seeded if the surface is much broken as the result; but if the obstructions have been widely scattered, it may be advisable simply to level the areas dug up in connection with the removal of the foreign vegetation and to seed those areas only. Kentucky bluegrass and white clover will be more useful than any other varieties. * * * After the surface has thus been cleared such pastures, as well as those which are now clear, may be expected to repay judicious top-dressing.

---

[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[2] Compiled from Massachusetts Sta. Rpt. 1910, pt. 2, p. 18.

It may be here pointed out that improvement of our pastures will not only increase the amount of stock which a farmer can keep, but it will be likely to increase the milk yield of a given number of cows, since in improved pastures the animals will be able to gather sufficient food in a much smaller number of hours, and will have leisure to ruminate, and to convert a larger portion of the feed consumed into milk.

In pastures in which the surface is occupied in considerable measure by rocks, top-dressing is of course likely to prove less profitable than in those which are free from such obstructions. It will be apparent, further, that the more nearly level the pasture the less probability that the materials used in top-dressing will be washed away.

It is believed that the basic slag meal used in the experiments referred to is peculiarly suited to meet the requirements of a large proportion of our pasture soils. Especially must this be true of those naturally poor in lime, with soils which are retentive of moisture, and where white clover is scantily produced. Slag meal is likely to produce less striking effects in pastures which now produce white clover abundantly, or in those having excessively dry soils. Its special fitness for the improvement of pastures deficient in lime and not now producing white clover is undoubtedly connected with the fact that it is rich in lime. Its tendency, therefore, is to sweeten soils which are naturally sour, and thus to bring them into such condition that clovers can thrive. It is now generally understood that clovers can not flourish in soils containing free acid. Basic slag meal, moreover, is a relatively low-priced fertilizer, and it may be pointed out still further that it has for many years been profitably used for top-dressing pastures in various parts of Europe, especially in England.

It has been found that on soils of the character of those used in these experiments a liberal application of potash is required in order to bring in a vigorous growth of clover, and under the climatic conditions prevailing a good, permanent pasture without white clover is considered a practical impossibility. Low-grade sulphate of potash was used in these experiments because it had seemed in other experiments to be especially favorable to the growth of white clover, but muriate and high-grade sulphate of potash produce like results and cost rather less in proportion to the actual amount of potash supplied than the low-grade sulphate, "and in localities where transportation counts as an especially important item they should perhaps be preferred, since to obtain an equal amount of potash it would be necessary to use them in only half the quantities required of the low-grade sulphate."

In regard to the best season for top-dressing, Prof. Brooks is of the opinion that for local pastures "top-dressing with a mixture of slag meal and potash salt had best be done in the autumn, but in all cases where the slopes are excessive it will be preferable to apply the materials in the early spring."

MAKING HAY.[1]

As A. M. Ten Eyck, of the Kansas station, points out, farmers can well afford to give more attention to the matter of quality in hay, and to this end it is important to know not only what hay plants are best adapted to a given locality and the best method of seeding them, but it is equally important to harvest and save the hay in such a manner as to secure the largest amount and best quality of product. "Good quality, as indicated by the bright-green color of well-preserved hay, will readily add a dollar or two per ton to the selling price."

---

[1] Compiled from Kansas Sta. Buls. 155, 175.

CUTTING THE HAY.

The common hay grasses and legumes differ somewhat in the stage of maturity at which each should be cut to make the best quality of hay, and farmers and feeders are learning that this difference in quality means not only a difference in market value but also a difference in feeding value. The stage of maturity at which grass should be harvested, in order to make hay of the best quality, varies somewhat with the different grasses and the use to which the hay is put. A safe rule applicable to all common grasses is to cut the grass just as it is beginning to bloom or just after the bloom has fallen. For cattle and sheep, hay from the early cutting is best, but for horses the later cutting is preferable. When cut in the early stage, grass is sure to make good, clean hay of prime quality, if the hay is cured well. Often a larger weight may be secured by cutting the grass after it becomes more mature, but the quality of the hay is not apt to be so good. If grass is cut when in full bloom the hay is sure to be more or less dusty. The over-mature hay is less palatable to stock and its feeding value per hundred pounds is usually less than the value of that cut at an early stage of maturity. * * * Timothy should be cut just as it is coming into bloom. When timothy is grown in combination with common red clover, it is necessary to cut the crop early in order to secure the clover before it has become too ripe to make good hay. The hay cut at this stage is best for feeding cattle and sheep. Timothy should not be allowed to stand until in full bloom, since, if cut at this stage, the hay will be dusty and especially objectionable for feeding horses.

To make the best hay for horses, timothy should be cut at the stage called "second bloom," which is really just when the grass has about ceased blooming and most of the blossoms have fallen. When timothy is cut at this stage, the greatest weight of hay is secured, and probably the greatest amount of nutrients, but the hay is more woody and less palatable than timothy cut earlier. * * *

Orchard grass, western rye-grass, perennial rye-grass, English blue grass, and Johnson grass quickly lose in palatability when nearing maturity, and should be cut for hay before the blooming stage. Other grasses, such as *Bromus inermis*, redtop, and tall oat-grass, retain their good qualities longer and make good hay if cut when in full bloom or after the blossoming stage. The annual cereal grains, such as barley, oats, and emmer, sowed sorghum, and Kafir, make the best hay if cut when the grain is in the milk or at the soft-dough stage. It is best to cut millet for hay as soon as it is fully headed, before the bloom forms. Cut at this stage, the hay is certainly less woody and more palatable than is the hay made from the more mature millet. The poisonous principle in millet which causes it to be injurious to stock, especially to horses, does not seem to depend upon the condition of the millet with regard to its maturity and the time of cutting. While the less mature millet is better relished, it may seem to give injurious results more quickly. * * *

Clover should be cut just when it is in full bloom, with a few of the blossoms turning brown. If it is cut before this stage, the hay will be lighter and more "washy," especially if fed to horses; while if the crop is left until the clover is mature, many of the leaves will be shattered or lost in harvesting. This will be a great loss, for the leaves are the most nutritious part of the clover, as they contain nearly two-thirds of the protein in the plant. * * *

Alfalfa should be cut for hay when it begins to bloom. Several experiments conducted at the Kansas Experiment Station and at other State experiment stations have shown that alfalfa hay has a higher feeding value when cut at an early stage of maturity, about one-tenth in bloom, than when cut in full bloom. It has also been observed that when cut at the beginning of the blooming period the next crop, under favorable soil and weather conditions, starts quickly and there is no delay in the growth of the alfalfa. * * *

The leaves of the alfalfa are much richer in protein than the stems, and the leaves drop off and shatter worse in cutting if the plants are allowed to become too mature before harvesting. For feeding horses, however, it is advisable and often recommended to allow the alfalfa to become more mature and to reach full bloom before cutting. The more mature hay may be fed to horses with less danger of injurious effects, which sometimes occur from feeding the immature hay. * * *

Cowpeas should be cut for hay when the first pods are beginning to turn yellow. Soy beans must not be left so long, but are ready to cut for hay as soon as the pods are well filled. If they are left until too mature, the leaves drop or shatter in harvesting, thus decreasing the palatability and the feeding value of the hay. Field peas and vetches make hay of good quality if cut when the pods are almost fully formed and some of the seed is beginning to ripen.

CURING THE HAY.

The most important factor in making good hay is favorable weather. Hay exposed to excessive rains is greatly injured in quality and in feeding value. This is especially true of hay from leguminous plants, such as clover and alfalfa. Every farmer knows that hay is injured by rain and dew, which cause it to bleach and to mold, and which take from it the natural aroma and palatability essential in hay of good quality. Not all are aware, however, that hay which is cured too much in the sun not only bleaches and loses leaves by becoming too dry but also becomes lighter in weight and less palatable.

When one cures hay of any kind, he should aim to expose it to the sun no more than is absolutely necessary. The best hay is therefore made by curing it largely in cocks rather than by leaving it spread over the ground in the swath or windrow. Hay in the swath and windrow is also more exposed to injury by rain and dew than is hay in the cock. Rain not only bleaches hay, thus lowering its market value, but the feeding value of the hay may also be very much decreased.

Hay cures more evenly in the cock than in the swath or the windrow. If left too long in the swath, the leaves become thoroughly dry, while the stems still retain a large amount of moisture. Such hay will not cure fully and evenly and is often put into the stack in a partly cured condition. If hay is raked before the leaves are dry and placed in cocks, the leaves continue to draw moisture out of the stems, thus allowing the hay to cure evenly.

Clover or alfalfa hay well cured in the cock in this way will keep perfectly in the stack or in the mow. When cured in the swath and windrow, the hay is often stacked in such condition that it may burn or spoil in the stack. Also, the greater breaking of the leaves which must take place in curing alfalfa or clover in the swath and windrow, makes the hay less palatable to stock, and less nutritious than hay which has been properly cured.

A large part of the hay made in the United States, however, is cured in the swath and windrow, or in shocks made up by bunching the hay with the horserake. When a farmer has a large amount of hay to put up and little help with which to handle it, he is compelled to do the work in the most rapid and economical way. Putting up the hay directly from the windrow is not only a saving of labor, but it enables the haymaker to do the work rapidly so that the danger of loss by exposure to the weather is lessened.

In the Central States it is common to cure timothy and clover hay in the swath and windrow, and to put it on the wagon by means of the hay loader, which makes the work more rapid and does away with the hard labor of pitching. In the large alfalfa and prairie-grass fields of the Western States, the common method is to use sweep rakes, by which the hay is taken directly from the windrow to the stacker. Where a large amount of hay is made, it is almost necessary to handle the crop by such a method. The method of curing hay in cocks is more applicable to the small farmer and to farmers who live where the market price of hay makes it profitable to handle it in this more expensive way.

The following general suggestions may be given with reference to making clover or alfalfa hay: As soon as the dew is off in the morning, start the mower; when the hay has wilted somewhat, run it over with a tedder if the crop is heavy and needs lifting; after an interval of a few hours, before the leaves have begun to get dry and brittle, rake the hay into windrows. Allow the hay to remain in this condition for a day or two, when it may be put into the stack or mow. If the plan of curing in cocks is followed, the hay should be placed in small cocks soon after raking. It will be necessary for it to remain in the field for from one to three days of drying weather before it is ready to be put into the stack.

It is possible to start the mower late in the afternoon, cutting until dark, raking the hay the next forenoon, and bunching or cocking as described above. Good hay may be made in this way, since the dew does not blacken the green hay, and even a light rain during the night may not greatly damage it. There is some objection to this method, however, for making clover or alfalfa hay, in that the dew falling on the green hay in the swath seems to favor the development of white mold. Cutting only during the forenoon after the dew is off is perhaps the preferable method, provided the farmer can handle the crop rapidly enough in this way.

Hay is much more likely to be injured by the moisture on it than by the moisture in it. This should be an invariable rule: Hay should not be raked or bunched or placed in the stack or mow when there is moisture on it either from dew or from rain. Such hay is likely to mold in the cock or in the mow and is almost certain to heat, to blacken, or to "burn" in the stack.

Grasses cure much more quickly than do alfalfa and clover. The length of time required for curing grass hay will depend upon the kind of grass, upon the degree of maturity, and upon the weather conditions. In good weather most grass hays may be cut one day and stored the next. It is even possible to cut grass in the forenoon and to put it up in the afternoon.

Because hay requires rapid handling, it is not necessary to cure grass hay in the cock in good weather. In showery weather, however, it is a very good plan to rake the hay somewhat green, to cock it, and to allow it to cure. Grass hay will shed rain much better in the cock than will clover or alfalfa.

STORING THE HAY.

Hay should be stored in sheds or in barns. Grass hay sheds the rain better than does clover or alfalfa, and may be stored out of doors with little loss, provided the stacks are well made and covered. However, a good hay shed is a profitable investment on any farm. When hay is fed on the farm, the aim should be to store it in a convenient place, so that it may be conveyed to the stock with the least amount of labor. If possible, the hay should be stored, and the live stock fed, under the same roof. This will avoid the expense of handling the hay a second time and the loss from the breaking of the leaves and heads.

The most rapid way of putting up hay is by the use of sweep rakes and sweep stackers, or swinging stackers. This necessitates stacking the hay in the field where it is cut. This method of putting up hay is best adapted to those regions where hay is made on a large scale. On the average farm, the practical method is to load the hay on wagons and to haul it to the stack or mow. The hay is rapidly removed from the load and dumped into the mow or stack by means of the hayfork or the hay sling. Slings are often preferable to hayforks for unloading hay, on account of the cleaner and more rapid work which may be done by the use of the sling. For barn or shed storing, a carrier and track is usually most convenient. For field stacking, some form of hay poles with the pulley and rope, either with or without the track, is in general use.

Hay should not be stacked on the ground, but on an elevated bottom made of poles and brush. If hay is green or unevenly cured, it is apt to "burn" or spoil when there is no ventilation beneath the stack. Great care should be taken to keep the middle of the stack full, so that when the hay settles the stack will shed rain. There is no better grass covering for stacks than marsh hay. When the stack is finished and topped out, one should not fail to bind on the cover with good hangers of wire attached to stones or heavy sticks of wood. As a rule, canvas or board stack covers are troublesome and expensive and not to be recommended. A farmer might better build a good hay shed than use such temporary means of protecting the stacks from rain. It is often advisable to have a canvas cover or two for temporary use when hay is stacked out of doors. * * *

Although the methods described above are the safest and the most satisfactory, it is a very common practice to put clover hay into the mow in a partially cured condition, perhaps on the afternoon of the same day the hay is cut. Green or partly cured clover put into a tight barn will become very hot, but it will not "burn." Such hay may come out in good condition for feeding, but with a brown color which injures the hay for selling on the market. It may be practicable also to store clover while green in raised-bottomed sheds, according to the plan which is now being used in this State for storing green alfalfa. It is now becoming a common practice in the more humid sections, where the method of farming is intensive rather than extensive, to protect the hay in the field by covering the cocks with canvas or with paper caps. There is little question regarding the practicability and economy of such a practice on small farms, and there is little question also but that the same method may be used profitably when alfalfa and clover are put up on a large scale. The canvas covers are doubtless to be preferred, since they are more durable and are more easily handled than are the paper caps. * * *

It is a common practice in the Middle and Eastern States to salt the hay when it is put into the stack or mow. In Kansas this practice is not usually followed except by certain farmers who stack alfalfa hay in a green or partially cured condition, and apply salt or lime for the purpose, as they claim, of preventing the hay from heating. There seem to be no sufficient data to prove that the application of lime or salt prevents hay from heating. No work along this line has been reported by experiment stations, and the reports of farmers vary. If the application of salt or lime prevents the heating of green or partially cured hay, this power is probably due to the influence which the salt or lime has in checking the growth of microbes or fungi which cause the fermentation that develops heat. In the same way, lime or salt may prevent the molding of hay.

There is little question but that the salted hay is relished better by stock. The fact that cattle eat the hay with greater relish may be the cause for the opinion among farmers that salting preserves the hay or makes it keep better. The application of a small amount of salt to the new hay in stacking may be recommended even when hay is well cured. The application of from 2 to 4 quarts of salt per ton is usually sufficient, but if the hay is green or only partially cured, more salt may be used. As far as the writer knows, there is no advantage in using lime to prevent the heating of hay, and salt should be preferred, since it adds palatability to the hay. So far as known, no injurious effects result from feeding the limed hay.

A FRESH-AIR BROODER.[1]

It is a general experience that loss of chicks during the early period of their life in brooders is apt to be large despite the utmost care and attention. The mortality of brooder chicks has therefore been the subject of considerable investigation by the experiment stations. Raymond Pearl, of the Maine station, has come to the conclusion that the trouble is in part at least due to fundamental defects in the ordinary type of bottom-heat hot-air brooder commonly used, viz, (1) too much floor heat, (2) poor ventilation, and (3) inconvenience, expense, and wear and tear of moving the brooders about when they "are operated in small colony houses, and the same houses are used for growing the chickens on the range throughout the summer."

---

[1] Compiled from Maine Sta. Bul. 193.

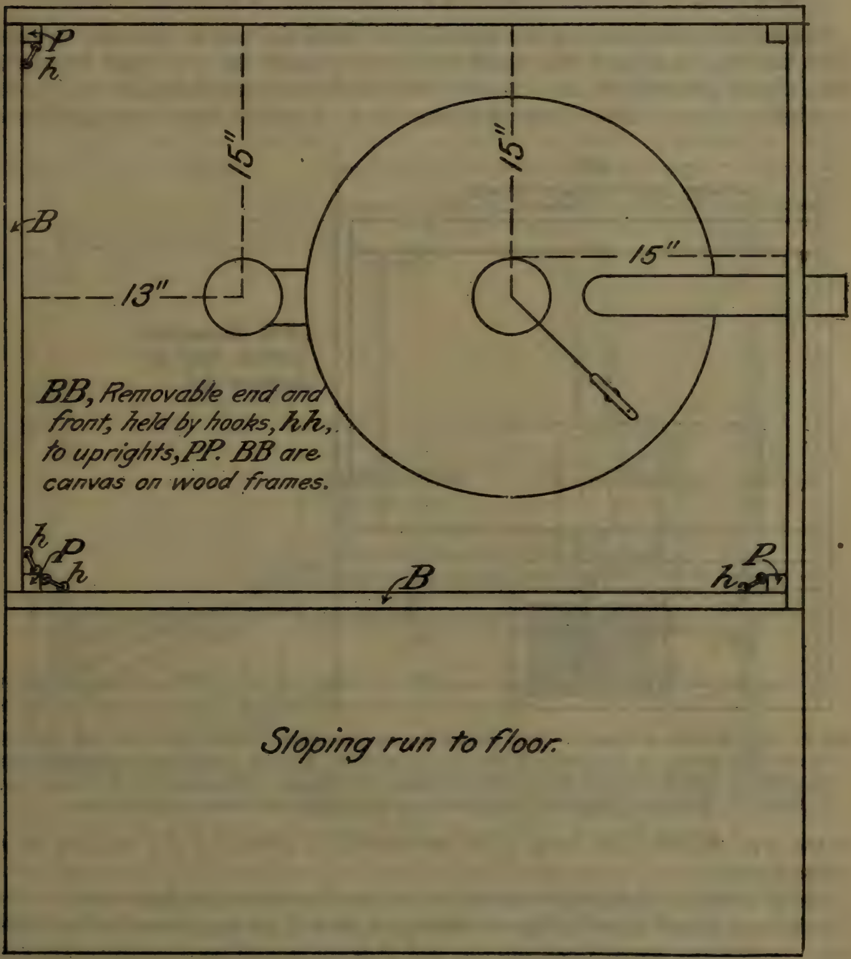

P
h
B
15"
15"
15"
13"
BB, Removable end and front, held by hooks, hh, to uprights, PP. BB are canvas on wood frames.
h
P
h
B
P
h
Sloping run to floor.

FIG. 1.—Floor plan of fresh-air brooder.

As a result of comparative tests of different makes of brooders, a brooder was designed which it is believed has decided advantages over ordinary types. The advantages claimed are "that it is possible to rear in this brooder a larger number of chicks in proportion to the number originally put in than in any other brooder with which the station has had any experience." The mortality is not only relatively low, but the chicks are healthier and thriftier. "The second advantage lies in the great saving of labor which is effected by the use of the new brooder. The fact that the brooder never has to be removed from the house where it is operated means a decided economy."

Describing the construction of this brooder it is stated that—

> The primary point aimed at was to make it a "fresh-air" and a "pure-air" brooder. With this idea in mind it was thought advisable to make the wall of the brooder in some degree permeable to air. To meet this requirement the walls and cover of the brooder are made of cloth. Essentially the brooder is a cloth box containing a hover of the type in which the lamp fumes are conducted outside of the building by an exhaust pipe.
>
> These brooders are built permanently into the houses which they occupy. Two brooders are placed in each colony house, one in each of the back corners of the building. In this way one end wall and the back wall of the building form two of the sides of each brooder. The remaining side and cover are made of cloth tacked on light wooden frames as shown in the working drawings.
>
> The floor of the brooder stands 10 inches above the floor of the house. From the front of the brooder a sloping walk extends down to the house floor, reaching in width clear across the whole front of the brooder. The cloth front and side of the brooder are not permanently fixed in position but are removable panels, which are held together and to the frame work by hooks and eyes (see fig. 1). The cover is hinged in the middle in such a way that it can be either half opened or entirely opened and folded back out of the way. In consequence of this arrangement it is possible to regulate with great nicety the amount of air which shall be admitted to the brooder.

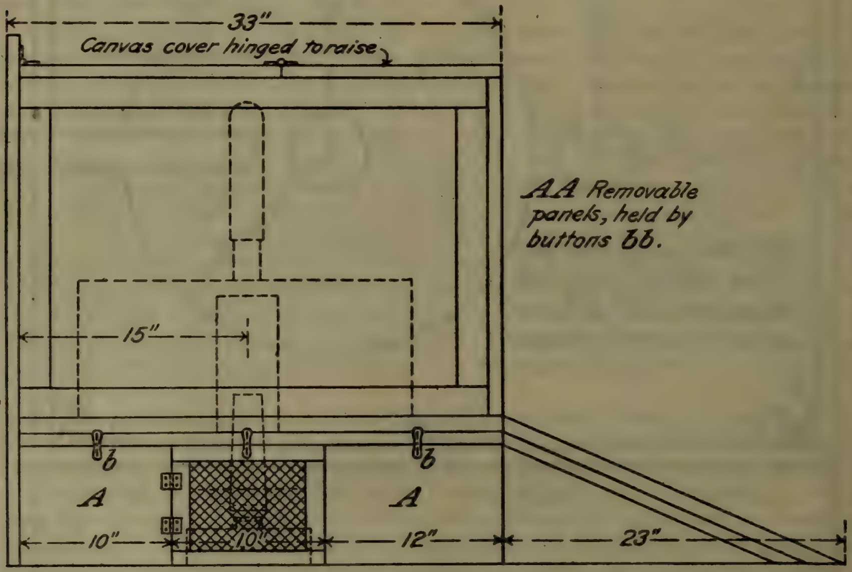

33"
Canvas cover hinged to raise
AA Removable panels, held by buttons bb.
15"
b
b
A
A
10"
10"
12"
23"

FIG. 2.—End elevation of brooder. Note sloping run to floor, hinged cover, removable side panel *AA* on base of brooder. In the center of this is a small door made of ¼-inch mesh galvanized wire. Through this door the lamp is withdrawn for filling and cleaning. The panel *AA* is removed when the brooder is dismantled, and the whole superstructure is then packed away under the base.

Either the front or the side panel may be tilted out as much as desired at the base, thus admitting air there. Furthermore, by partly opening a panel and the cover it is possible to insure that there shall be a circulation of air through the brooder at all times.

A modification of a common make of hover is used, in which the lamp is placed inside the house directly under the brooder instead of in a box outside the house.

The reason for this modification is that in this climate, where one is likely to have bad weather during the early part of the hatching and rearing season, with heavy winds, snow, and rain, it is much easier and more satisfactory to take care of the lamp inside the house than from a small box outside the house. Another modification is that in the hovers which are installed in these brooders an especially heavy insulation is put on top of the drum to reduce the loss of heat by radiation in extremely cold weather early in the spring.

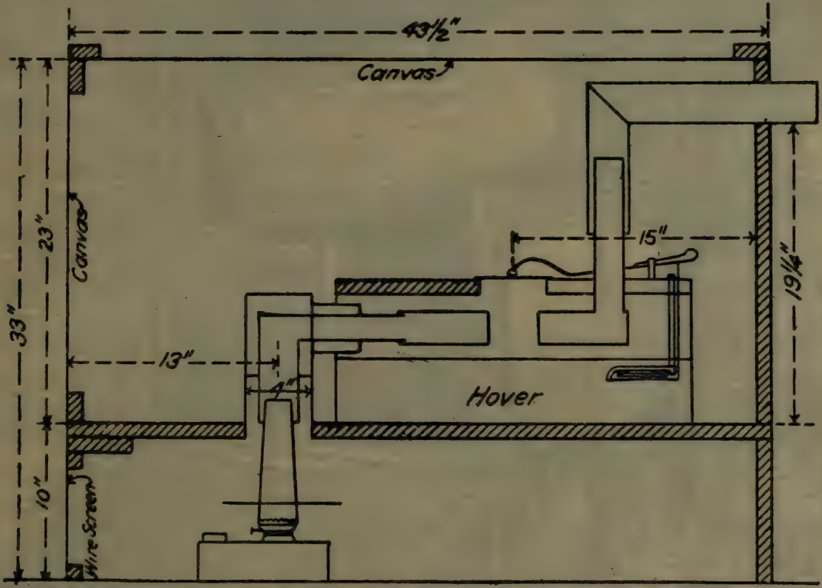


FIG. 3.—Section through middle of brooder. Note cloth cover and side, large space between floor of brooder and floor of house, in which the lamp is placed while the brooder is in operation, and which serves as a storage place for the whole upper part of the brooder when the latter is not in use.

One of the essential points about the brooder is its compactness in storage and the fact that all the parts may be stored in the base of the brooder itself. In this way the labor expense of carrying back and forth parts from a storage house each year is avoided. To bring about this result the size of the base is so calculated that all the parts of the brooder may be inclosed in it. The way in which this is done is apparent from an examination of figure 2. It will be seen that the end of the brooder base (marked *AA* in the diagram) is removable, being held in place by buttons *bb*. When the end of the brooding season is reached and there is no further use for the brooder that year, the side and front end panel of the brooder are removed, the canvas cover folded back and tacked to the wall of the building, and the hover dismantled. All of the parts are then shoved under the brooder floor and the panel *AA* put back in place again. The floor of the brooder is removable, so that it and the floor underneath may be cleaned and disinfected. By removing the legs the hover may be stored in the brooder base along with the other parts, or if one does not desire to do this the hover may be suspended close up to the roof of the building. In that position it will be impossible for the birds to roost on it. Of course, all removable parts should be taken from the hover before it is hung up in this way. These parts may be stored in the brooder base. After the chickens are out of the house in the fall the parts of the brooder are taken out, thoroughly cleaned and disinfected, and then the whole is reassembled and made ready for the hatching season of the next year.

Detailed working drawings of the brooder are given herewith. Figure 2 shows the end elevation of the brooder; figure 3 shows a section through the middle of the brooder; figure 1 shows a floor plan; figure 4 shows the brooder in operation. * * * All dimensions are given on these drawings and from them it should be possible for anyone to construct the brooder for himself.

As material, any sort of planed lumber may be used. Probably pine will be found satisfactory and economical in most cases. Spruce or hemlock may be used to build the base, if one desires. For the cover and removable sides almost any sort of cloth may be used. Here we have employed the lightest weight canvas (duck) that could be obtained locally. Burlap may be used, or even unbleached cotton cloth in localities where the outside temperature is not too low.

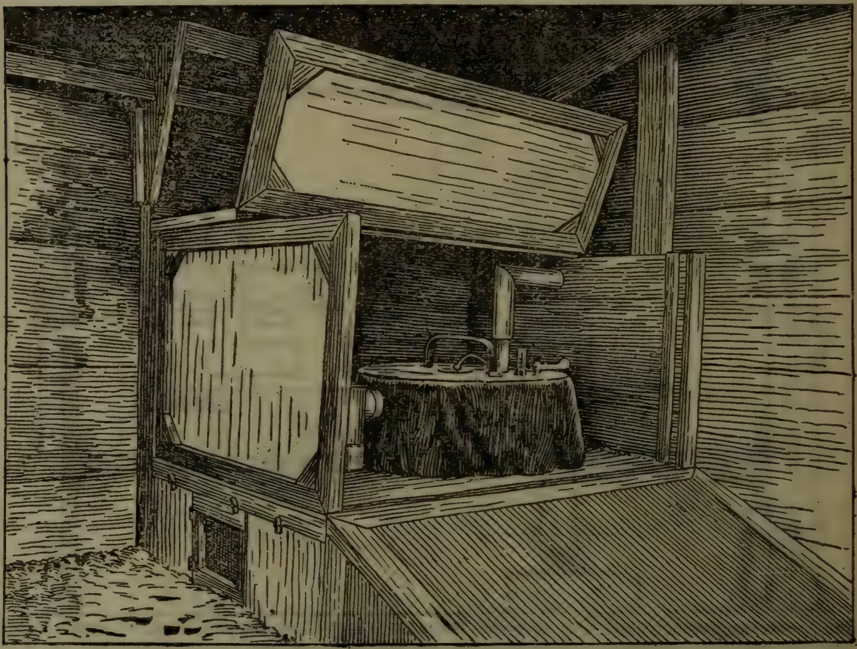


FIG. 4.—Brooder installed and ready for operation.

ROOSTING CLOSET FOR POULTRY.[1]

In the curtain-front type of poultry house used at the Maine Experiment Station a feature of the original plan on which considerable stress was laid was the canvas curtain in front of the roosts.[2]

This curtain, together with the back wall of the house and the droppings board unde the roosts formed a closet in which the birds were shut up at night during cold weather.

---

[1] Compiled from Maine Sta. Bul. 193. [2] U. S. Dept. Agr., Farmers' Buls. 227, p. 28; 357, p. 21.

When the curtain-front house was first devised it was thought essential to provide such a closet to conserve the body heat of the birds during the cold nights when the temperature might go well below zero. Experience has shown, however, that this was a mistake. Actual test shows that the roosting closet is of no advantage, even in such a severe climate as that of Orono. On the contrary, the birds certainly thrive better without the roost curtain than with it. It has been a general observation among users of the curtain-front type of house that when the roost curtains are used the birds are particularly susceptible to colds. It is not hard to understand why this should be so. The air in a roosting closet when it is opened in the morning is plainly bad. The fact that it is warm in no way offsets physiologically the evils of its lack of oxygen and excess of carbon dioxid, ammoniacal vapors, and other exhalations from the bodies of the birds.

For some time past it has been felt that the roosting closet was at least unnecessary, if not in fact a positive evil. Consequently the time of beginning to close the roost curtain in the fall has been each year longer delayed. Finally, in the fall of 1910, it was decided not to use these curtains at all during the winter. Consequently they were taken out of the house, or spiked to the roof, as the case might be. The winter of 1910–11 was a severe one. On several occasions the temperature dropped to 30° below zero. Yet during this winter the mortality was exceptionally low and the egg production exceptionally high.

In view of this experience the station has decided to discontinue the use of the roost curtain. It would seem to be generally undesirable or at least unnecessary.

EXHIBITION CONTESTS FOR IMPROVING DAIRY PRODUCTS.[1]

Exhibitions of dairy products for prizes have proved to be of great value to dairymen wherever tried. That much interest is being manifested is shown by the large number of entries from many States at recent exhibitions. At the International Dairy Show at Milwaukee, for example, there were entered 115 samples of milk and cream from all sections of the country.

A. C. Baer, of the Wisconsin Experiment Station, in commenting upon the educational value of these exhibitions states: "These contests have proved that milk and cream produced and handled under sanitary conditions and kept at a low temperature can be shipped thousands of miles and remain sweet for weeks. The contests have also helped to point out to the dairyman the common defects in milk and cream, and have suggested remedies to overcome the difficulties."

Mr. Baer also emphasizes the need of more local contests.

A friendly, neighborly milk and cream contest can be held annually in every city of the country. A contest of this kind brings the milkmen and dairymen together with common interests, and the educational value resulting will be no small gain to a community. The experience of men who have conducted these milk and cream contests has demonstrated the fact that milk or cream can be scored with reasonable accuracy for flavor and odor, bacteria, chemical composition, and keeping quality.

---

[1] Compiled from California Sta. Circs. 48, 60; Pennsylvania Sta. Bul. 93; Hoard's Dairyman, 42 (1911), No. 47, pp. 1449, 1460; Pract. Dairyman, 5 (1912), No. 21, p. 329.

Below is given a copy of the score card which has been used with success:

SCORE CARD FOR MILK.

Class.............. Exhibit No..............

Item.	Perfect score.	Score allowed.	Remarks.
Bacteria	35		Bacteria found per cubic centimeter
Flavor and odor	25		Flavor Odor
Visible dirt	10		
Fat	10		Per cent found
Solids not fat	10		Per cent found
Acidity	5		Per cent found
Bottle and cap	5		Bottle Cap
Total	100		

Another important phase of the work has taken the form of butter-scoring contests such as have been conducted by the dairy divisions of the Pennsylvania and California stations. These contests are conducted somewhat as follows: Each contestant at specified times ships an entry of butter and a record of methods used to the dairy division, the method blanks for this purpose being provided by the station. The butter upon arrival is numbered and any marks of identification are removed so that when scored no partiality can possibly be shown. The scoring is done under direction of some expert. After the butter is scored a letter is sent to each contestant giving the score and criticism by the judge, together with suggestions as to methods of improving the butter. The score card used at both the California and Pennsylvania stations was that of the National and State Associations with such explanations as were necessary. The following is a copy of the score card used by the University of California:

BUTTER SCORE CARD.

Name ....

No.......................... Date..............................

Perfect.	Score.	Check.
45	Flavor	Rancid Overripe cream Bitter cream
25	Body	Worked too much Worked not enough
15	Color	Too high Too light Mottled Streaked
10	Salt	Too much Not enough
5	Packing	Poor packing Poor package
100	Total	

Scored by..

Per cent of moisture..............................
Per cent of salt..............................

The butter that scored highest (96 per cent) was made as follows:

A fair grade of gathered cream testing 30 per cent was pasteurized at 180°, cooled to 48°, and 14 per cent of good commercial starter added. The cream was not ripened, as it contained 0.52 per cent acidity. It was held 2 hours at 48°, and churned. Time of churning was 40 minutes, and the granules were the size of wheat. The buttermilk had a temperature of 53°, and tested 0.02 per cent. The manner of washing was spraying at 50° until the water ran clear from the churn, then adding as much water at 50° as there was buttermilk. There was one working.

In making the butter that scored lowest (89 per cent) in the same entry the "cream in fair condition, age 2 days, testing 37 per cent, was ripened for 5 hours to an acidity of 0.55 per cent. Twenty-three per cent of starter was used. When churned it had a temperature of 51°, and the buttermilk was 53°. There were two washings at 54°, and one working."

With another sample of butter which scored 95½ per cent the "graded cream one day old was ripened at 62° to 0.42 per cent acidity by the aid of 18 per cent of starter. It was then cooled to 54° and churned immediately. The buttermilk and wash water were 56° and 58°. Standard culture, and approved equipment were used."

In discussing the general conditions as to flavor, body, and color of the butter as brought out in these scoring contests at the California station, Prof. Davis states that—

Fully 90 per cent of the unfavorable criticisms on flavor are due to conditions of handling, over which the buttermaker has no control. Unclean, cowy, barny flavors are the result of dirty methods. Stale, overripe, and sour are terms used to designate the flavors which are the result of too long holding of cream. Rancid flavor is a serious defect resulting from extensive decomposition, whereby the nonvolatile fats are acted upon by bacteria, become volatile and escape. Cheesy flavor is the result of a fermentation, but this time it is the proteid materials—casein in cream, curd in butter—which are acted upon. It is an injustice to the consuming public that such cream be manufactured into butter.

As a contrast to the large number of defects in flavor, for which the buttermaker is not responsible, are the small number of criticisms under flavor, due to methods of manufacture. They include fishy flavor, oily flavor, and metallic flavor. The two former may be closely associated, although oily flavor is perhaps the result of too high ripening, churning, and working temperatures. Fishy flavor is generally recognized by authorities on the subject to be the result of overworking butter which is made from high acid cream. The remedy for these defects is obvious. Metallic flavor is probably due to the pasteurization of a rich cream. It is likely to occur when cream which tests much over 35 per cent is pasteurized. Metallic flavor may also be due to holding milk or cream in rusty containers.

Next in importance to flavor is body. Body refers to the firmness or substance of the butter. On the San Francisco Dairy Exchange, the body of butter classed as extras must be "firm and solid, with perfect grain or texture, free from salviness." Under this head is also included texture, or grain, which refers to the appearance rather than to the firmness or substance. Perfect texture shows a grain which may be spoken of as having a flinty appearance when a trier full is broken. Body and texture influence the brine, both as to appearance and amount.

Weak or greasy body is due to high temperatures and overworking, whereby the fat is made to become soft, and grain is destroyed. Cooling the butter fat quickly after churning and working at a low temperature tends to produce a brittle, or crumbly body. Milky brine is due to lack of thorough washing. Leaky butter is caused by a lack of thorough incorporation of wash water, through washing in a fine granular form with cold water, then working insufficiently. Leaky butter is objectionable to consumers because of appearance. The presence of this free moisture, however, is no indication of a high moisture content. Dry body is caused by excessive churning, or high churning temperatures.

The importance of proper temperatures and manipulations is apparent. These can be determined only by a careful study of local conditions, with regard to season and the feed which the cows receive. In the spring when pastures are opened, the percentage of soft fats is usually increased, necessitating lower temperatures than at periods of the year when the butter fat is harder as a result of dry feed. The number of revolutions for working varies with the make of churn. The only general rule to follow is to work sufficiently to dissolve salt, prevent mottles, and leave butter with good texture.

The most serious defects under color are mottles, wavy or streaked. They refer to a difference or unevenness of color, and appear in butter as irregular, lighter, and darker portions, and often as spots.

The general opinion regarding these defects seems to be that they are the result of uneven salting. This is in part the cause, but another factor enters, and that is the presence of buttermilk or casein compounds. Salt as put into butter should be dissolved by the water present, and a brine solution result. If butter contains casein compounds, left in by failure to remove all the buttermilk, they are acted upon and hardened by this brine solution. Consequently, when the butter is worked streaks and spots result. Where these streaks and spots occur the lighter portions are due to the presence of casein compounds. The yellow and clear portions are free from these, and the fat is surrounded by clear brine. Well-washed butter very seldom shows mottles, unless the salting is done unevenly.

Mottled or streaky butter, then, may be prevented by churning at a low temperature to keep the butter in fine granules, washing thoroughly, and working sufficiently to insure equal distribution of salt. Even under these conditions a certain amount of buttermilk will be retained within the granules, but not sufficient to cause these defects.

Mottles or streaks do not necessarily detract from the palatability and wholesomeness of butter, but the fact that present-day markets are governed, to a great extent, by appearances makes it the more important that every buttermaker guard against them.

At a recent cheese scoring exhibition at the College of Agriculture of the University of Wisconsin an average of 89.57 per cent was placed upon 7 entries of cheese.

The main defect was an unclean, sour flavor and a moist, weak, short texture. Some cheeses were not firmed sufficiently before heating, others lacked the proper cook, and some were dipped too soon. The cheese that received the highest score was worked 30 minutes before heating and cooked to 114°. Sixty-five minutes elapsed from cutting to dipping and the water content of this cheese was 38.5 per cent. At this season of the year the proportion of fat to casein in milk is higher. This gives a tendency to make a soft, slushy curd and a weak boiled cheese. This can be overcome to a certain extent by salting more heavily.

BLIND STAGGERS OF HORSES.[1]

In a bulletin of the Kansas station, T. P. Haslam gives a brief summary of investigations of the disease of horses variously known as staggers, blind staggers, sleepy staggers, and mad staggers. This disease has occurred in outbreaks of greater or less severity in many sections of the United States, Kansas, Texas, Louisiana, North Carolina, Delaware, and Arkansas having apparently experienced the most trouble. According to N. S. Mayo, of the Virginia station, losses from this disease are also at times large in Virginia.

The first symptoms of the disease as described by Mayo [2] are usually a refusal of food and a desire for water, often accompanied by some difficulty in swallowing.

> Following this there is dullness and dropping of the ears, partial or complete blindness, loss of consciousness, delirium, and death; or in a few cases, recovery. Some cases become violent, running over obstacles, through fences, or destroying stalls in a frenzy of excitement. Animals suffering from this form ("mad staggers") are irresponsible and must be approached with caution. If the animal does not die in this stage of the disease, it usually becomes quiet or stupid ("sleepy staggers"), leans against the side of the stall or manger, or pushes its head against a wall, often standing with the legs braced. Sometimes animals in the stupid state of the disease are thrown into a frenzy by the least excitement or irritation. Animals suffering from this disease, if they can be induced to move, generally go in a circle, either to the right or left, depending on which side of the brain is most seriously diseased * * * [The] disease is not contagious and attacks no animals except horses, mules, and asses.

A severe outbreak of the disease in Kansas was investigated by Mayo at the Kansas station in 1891 with a view of ascertaining the cause of the disease. The conclusion was reached that it was due to mold which had badly damaged the small crop of corn grown that year because of dry weather. In 1902 and 1906 there were severe outbreaks in various parts of the State. There has also seemed to be a continual loss of horses from staggers in any locality in which much corn of an inferior grade is fed.

In investigations made during the outbreak in 1906 Haslam found that "in some localities cases which were reported as staggers were in reality typical cases of parasitism produced in horses by the palisade worm (*Sclerostoma equinum*, or *Strongylus armatus*) in the intestines and blood vessels, the error arising from the similarity of some of the symptoms of the two diseases. Those familiar with the course of either disease rarely make this mistake."

It is stated that there are few authentic records of cases occurring in Kansas with horses which had not been fed on corn, although in other States severe losses of horses have occurred when the grass in the pastures became moldy.

> From a practical point of view, the relation between corn and staggers has been quite thoroughly demonstrated. The question naturally arises, which of the micro-

---

[1] Compiled from Kansas Sta. Bul. 173.

[2] Southern Planter, 73 (1912), No. 2, p. 153.

organisms present on the corn is the specific cause of the trouble, or whether a too exclusive corn diet or the immature corn possesses the injurious properties. These questions must still remain open, but the indications are that the cause of the trouble is contained in the moldy portions, as sound corn from the same bin was fed to more than a dozen horses and mules for months without producing any disorder. * * *

Dr. Carlo Ceni, of Italy, and his pupils report that the molds are capable of producing poisons, but only at certain seasons of the year, and that in the winter as well as in the middle of the summer they are entirely inactive. Another fact of great interest has been developed by Dr. M. Otto, of Germany, that while the extracts of two species [molds] obtained from Italy are very marked poisons, those from the same kind of molds growing in Germany possess little or no poisonous properties. The influence of the time of the year and the locality in which the molds grew may perhaps explain why loss of stock does not always follow the use of moldy feed and why pellagra has not always been found in corn-growing districts.

Veterinarians accustomed to treating this trouble usually cure a small majority of the cases treated if the treatment is begun before the disease has progressed very far * * * [but] it is very evident that the best means of combating this disorder consists in prevention. No unsound corn should be fed to horses. If it is necessary to feed a poor grade of corn it should be shelled and thoroughly cleaned with a fanning mill. Very good results have been obtained by the so-called floating of corn before feeding, which consists in pouring it into water. The moldy grains, being lighter, rise to the surface and may be skimmed off. Good results are reported by some who have ground the well-cleaned corn and mixed it with equal parts of bran and oats.

As Mayo points out, no moldy, wormy, or decomposing corn or other food should be fed. "Corn that has been attacked by the green corn worm at the tip and that is moldy is especially dangerous."

ADOBE AS A BUILDING MATERIAL.[1]

In a bulletin of the Colorado station, J. W. Adams calls attention of settlers in the drier regions where building materials are scarce or costly to the advantages of adobe buildings. He says:

An adobe house, properly built, will cost no more than a sod house, and yet be as permanent, attractive, and comfortable as it is possible to build a house. They do not settle after they are dry. Mice do not work in them if they are protected at the foundation. They are superior to concrete or cement block houses in that they are nonconductors of heat and cold. They never sweat or become frosty on the inside, and rain does not wet the walls through as it does in many concrete houses. The labor required to build an adobe house is no more than that required to build a similar house of sod or concrete. * * *

In planning a building of this kind, we should consider the kind of roof to be used and make the dimensions such that it may be covered with the least possible waste of material. The dimensions being decided upon, stake out the foundation carefully. If concrete foundation is to be used it will be necessary to make forms for the foundation. Then set good straight posts in each corner and at intervals of 14 or 16 feet on the inside of the wall. Line and plumb these posts very carefully. If desirable, short stakes may be used instead of posts until the walls get above the stakes, then these may be replaced by posts as high as the walls are to be. Good, straight 2 by 4 posts are all right. The stakes being lined and plumbed carefully, you are ready to begin the wall.

---

[1] Compiled from Colorado Sta. Bul. 174.

Now take your sod plow, select a patch of prairie where the grass is thick and tall—if possible (avoid sandy soil), and plow a thin sod. You may plow enough at one time for the entire building, if desired. Select a place for mixing the adobe near your water supply, if possible. With small buildings, it may be desirable to mix the adobe in the center of the building, but it will not pay unless your building is so located that you can not drive around it. Haul your sod and spread it in a circle not to exceed 12 to 14 feet in diameter. Make the pile about 8 inches deep. Now, throw the water on this pile until you think you have enough to wet the whole pile thoroughly. Then get on a horse and lead one or two others, and make the horses tramp around and around, turning very short. If they are allowed to go in a larger circle they will avoid stepping on the higher places. After you have tramped a few rounds you will discover dry places in the pile. Throw more water on these places and continue tramping and throwing on water until the whole mass is mucky. The pile will have a tendency to spread out, and some places will be sloppy while others are not wet enough. Then lead your horses out and take a manure fork (a six-tined fork is best) and throw the outer edges of the mass toward the center, taking care to throw the drier parts to the wet places and vice versa. Tramp again, adding water if needed. It is usually best to throw the edges in the second time in order to get the mass evenly mucked.

If you have been unable to get sod with plenty of grass and roots to form a fiber in the mud, you should add a small amount of straw, hay, or trash of some kind. Spread it over the mass after it is mixed, as above described, and tramp again until the straw is all tramped into the mud. When the mass is thoroughly wet and thoroughly mucked, and of such a consistency that it can be handled with a manure fork, it is ready to be put into the wall. Throw this on a wagon or sled, discarding any chunks that may not have been mucked, draw it alongside the wall and place it in the wall with a fork. Drop it into the wall with sufficient force to make it settle together solid, leaving no holes or spaces. Make as thick a layer as you can without its spreading out too wide. Let it spread over the edge of the wall an inch or two on each side. Be sure that the mud comes out to the edge of the wall at all places, otherwise there will be holes, or flaws, in the wall when trimmed. As soon as you have made one layer around the wall, if the weather is hot and dry you may be able to start around again placing a layer on top of the first, being careful to make the mud fit down on the first clear out to the edge of the wall to prevent flaws. When you have a layer about 12 inches thick, let it stand until it is firm, but not dry. Select a board with straight edges, 14 to 16 feet long, and as wide as the thickness of the wall. If the wall is to be more than 12 inches thick, two boards of the proper width may be cleated together to make the required width. Lay the board on top of the wall with one edge against the posts, get upon the board and trim straight down each edge of the board with a hay knife (see fig. 5). When the walls are trimmed all around in this manner they are ready for another layer of mud. Continue until the walls are the desired height. Never allow a layer to become hard before it is trimmed, or you will have a hard job.

The rapidity with which this work may be pushed depends upon the weather. If the weather is hot and dry, you may be able to make an average of 6 inches per day from start to finish. Some days you may put a foot and then let it rest a day or two. If the weather is cool or damp, the work will go correspondingly slower. In early spring or late fall the work is very slow, and one should not attempt to build adobe in winter.

Keep watch of your walls. If they are not drying rapidly, you had better lay off a day and allow the walls to dry. It is a very good plan to build 2 or 3 feet and then let it stand a week or so and then build 2 or 3 feet more, and so on until the wall is done.

The frames for doors and windows may be put in place and the mud built to them. But a better way is to trim the openings for doors and windows and fit frames into the openings as soon as the walls are as high as the frames are to be. These frames should be of 2-inch stuff. The top of the frame should be as wide as the thickness of the wall and should extend into the wall a little. When the frames are in place you may build over them with the adobe. The walls will shrink in drying and draw away from the frames a little, leaving a crack. These cracks may be plastered up with a trowel.

If the roof is to be of shingles or iron it will be necessary to anchor the plates to the wall to prevent the roof blowing off. This may be done by putting 14-inch bolts through short pieces of 2 by 4 and planting them in the walls as you build so the top of the bolt will just reach through the plate. If adobe or sod roof is to be used the weight will be sufficient to prevent blowing off. The roof should be leak-proof to prevent water running down the walls and softening them.

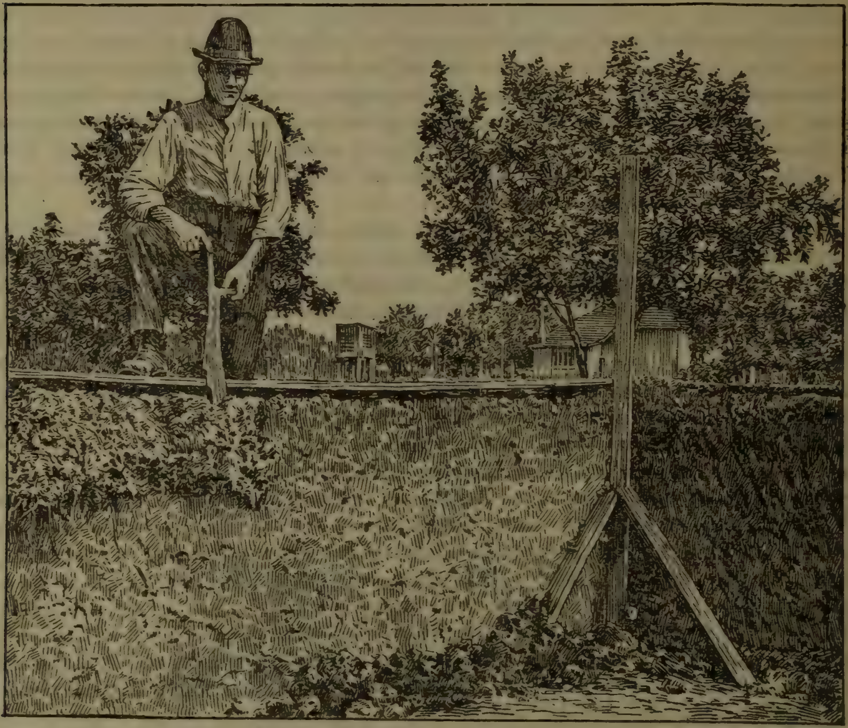


FIG. 5.—Trimming edge of adobe wall with hay knife.

Summarizing these directions for adobe construction, Mr. Adams emphasizes especially the following points:

"(1) Line [the] posts and plumb them carefully, and [the] walls are bound to be straight and plumb. (2) Be sure to make good joints between layers. (3) Never allow adobe to get hard before trimming. (4) Never allow dry or untramped chunks of sod to enter the wall. (5) Never allow water to settle against the walls."

An attractive as well as durable building may be secured by covering the outer walls with cement plaster and blocking off.

WHITE AND COLOR WASHES.[1]

There is no cheaper or more attractive means of improving the appearance and sanitary condition of the farmhouse and surroundings than the judicious use of white or colored washes. Such washes are easily prepared and applied. A recent Farmers' Bulletin of this department [2] gives directions for preparing standard whitewashes. A few formulas for washes not included in that bulletin and which have also proved satisfactory in use are given below:

According to the Alabama Tuskegee Experiment Station a unique and valuable use can be made of the white and colored clays which abound in many localities, viz, the preparation of washes for covering or kalsomining the exterior and interior of dwellings, schoolhouses, etc.

Where a clay is sand free all that is necessary is to mix it thoroughly with hot or cold water in order to obtain a consistency of the average good whitewash and to apply it to the rough surface in the usual manner. Where dressed lumber and hard-finished plastering are to be kalsomined the surface must be previously prepared and sized.

Sandy clay can also be used, but it must first be freed from sand by one of the following methods:

(*a*) Sift the pulverized clay through a fine sieve or a piece of coarse cloth. (*b*) Stir the pulverized clay thoroughly into a vessel partly filled with water; let stand 2 minutes. The sand and gravel will sink to the bottom, and the water, with its suspended clay particles, can be poured off. (*c*) Take a coarse bag, something like a flour sack; put half a gallon or so of the pulverized clay into it; dip this repeatedly into a vessel of water until the clay has been washed out. The sand in the bag may be thrown away, and a fresh batch taken and treated in the same way until a sufficient quantity to suit your purpose has been gotten out.

Where a wash is desired which does not easily rub off, one of the following methods is proposed:

(*a*) For every gallon of color wash stir in a pint of glue size (glue that has been dissolved in water until it becomes the consistency of mucilage). (*b*) To every gallon of color wash stir in a pint of well-boiled starch or flour paste, being sure that there are no lumps in it. (*c*) For every gallon of color wash stir in a quart of thoroughly boiled sweet milk from which all the cream has been taken. (*d*) Boil a pound of rice in 2 gallons of water until a smooth paste is formed; strain through a cloth, and use the water the same as any other sizing.

The colors of the above clays may be blended by mixing one with the other, thus producing a variety of shades, or coloring matters like laundry blue (Prussian blue) may be introduced at very little extra expense.

An Australian whitewash, which it is claimed will not rub off, is prepared by "dissolving 2 pounds of ordinary glue in 7 pints of water, and when all is dissolved adding 6 ounces of bichromate of potassium dissolved in a pint of hot water. Stir the mixture up well, and then add sufficient whiting to make it up to the usual consistency, and apply with a brush in the ordinary manner as quickly as possible. This dries in a very short time, and, by the action of light, becomes converted into a perfectly insoluble waterproof substance, which does not wash off even with hot water, and at the same time does not give rise to mold growth, as whitewash made up with size often does. It may be colored to any desired shade by the use of a trace of anilin dye or powdered coloring, while by the addition of a small proportion of calcic sulphite its antiseptic power is much increased."

---

[1] Compiled from Alabama College Sta. Bul. 136; Alabama Tuskegee Sta. Bul. 21; Daily Cons. and Trade Rpts. [U. S.], 14 (1911), No. 215, p. 1209; Queensland Agr. Jour., 17 (1906), No. 2, p. 89.

[2] U. S. Dept. Agr., Farmers' Bul. 474.

A recent consular report states that a traveler in the rural districts of Uruguay will be struck by the fine white color of the farm buildings even during the wet season. This neat effect is secured by the use of a whitewash prepared by macerating the sliced leaves of the common cactus in water for 24 hours, producing a liquid of creamy consistency, to which lime is added and the whole well mixed. "When applied to any surface, be it of wood, brick, iron, or other material, a beautiful pearly white appearance is produced, which will endure through storms and frosts for many years." It is suggested that in sections of the United States where the cactus is abundant it might be utilized with advantage in this manner.

These whitewashes, like all those which contain milk, flour, glue, or other organic matter, are not recommended for use in damp interior places.

Issued May 25, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

[illegible]

FARMERS' BULLETIN No. 500.

THE CONTROL OF THE BOLL WEEVIL.

BY

W. D. HUNTER,

In Charge of Southern Field-Crop Insect Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 4, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript prepared by Mr. W. D. Hunter, of this bureau, entitled "The Control of the Boll Weevil."

The matter contained in this manuscript is extracted largely from Bulletin 114, of this bureau. That publication is a comprehensive treatment of all phases of the boll-weevil problem. The object in reprinting a portion of it is to place the matter relating to practical control in form for more economical distribution among the planters.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction.......... 5
Basis for means of repression.......... 5
Summary of control measures.......... 11

THE CONTROL OF THE BOLL WEEVIL.

INTRODUCTION.

The matter contained in this bulletin is extracted largely from Bulletin No. 114 of this bureau.[1] That publication contains a rather exhaustive account of the history of the boll weevil in the United States and in other countries, its life history and habits, and numerous methods of control that have been suggested from time to time. The reader is referred to the larger publication for much fuller information regarding many of the points discussed in this circular.

The work on the boll weevil is being continued, and there are definite indications of a successful outcome from experiments in control that will add still further to the planters' ability to combat the pest. This bulletin, however, contains a brief outline of the methods which have been tested under various conditions and sums up the present available knowledge concerning the subject of control.

The difficulties in the way of controlling the boll weevil lie both in its habits and manner of work and in the peculiar industrial conditions involved in the production of the staple, cotton, in the Southern States. In all stages except the imago the weevil lives within the fruit of the plant, well protected from any poisons that might be applied. The adult takes food normally only by inserting its snout within the substance of the plant. It frequently requires but 12 days for development from egg to adult. The progeny of a single pair in a season may exceed 12,000,000 individuals. It adapts itself to climatic conditions to the extent that the egg stage alone in November may occupy as much time as all the immature stages together in July or August. All of these factors combine to make it one of the most difficult insects to control.

BASIS FOR MEANS OF REPRESSION.

In spite of the many difficulties involved in the control of the boll weevil certain generally satisfactory means of repression are at hand, and others may be found as the result of future work. They consist of both direct and indirect means. Those of an indirect nature are designed to increase the advantage gained by the direct measures and to increase the effectiveness of the several natural factors which serve to reduce the number of weevils. Thus the control measures constitute a combination of expedients, the parts of which interact in many ways. Naturally, the best results are obtained when the planter can put into practice all of the essential parts of the combination.

---

[1] Bul. 114, Bureau of Entomology, U. S. Dept. Agriculture, "The Mexican Cotton Boll Weevil," by W. D. Hunter and W. D. Pierce. Also issued as Senate Doc. No. 305, 62d Cong., 2d sess.

It is obvious that any method of controlling the boll weevil must depend upon full knowledge regarding its life history and the natural forces which tend to prevent its multiplication. Certain practices which upon superficial observation might be considered important in the control of the insect, upon investigation may be found to be of no avail whatever. In fact, in some cases what appear to be feasible means of control are worse than useless, because they tend to nullify the effects of natural forces which act against the weevil. This is notably the case with the practice of attaching a bar to a cultivator to jar the infested squares from the plants. As will be explained later, this practice is of advantage under only very restricted conditions. Throughout the greater part of the infested territory it is an assistance rather than a hindrance to the boll weevil.

There are seven features of the life history of the weevil that are of cardinal importance in control. These are indicated below.

(1) The weevil has no food plant but cotton.

(2) The mortality of the weevil during the winter is very high.

(3) The emergence from hibernating quarters during the spring is slow and prolonged until well into the summer.

(4) Early in the season, on account of comparatively low temperatures, the development of the weevil is much slower than during the summer months.

(5) The drying of the infested squares soon destroys the immature stages of the weevil contained therein.

(6) The weevil is attacked by many different species of insect enemies, the effectiveness of which is increased by certain practices.

(7) The weevil has but little ability to emerge when buried under wet soil.

Exactly how each of these features of the life history of the weevil affects plans for practical control will be explained in the following paragraphs:

In the case of many of the important injurious insects the problem of control is greatly complicated by the fact that the pests can subsist upon more than one food plant. In some cases a single species attacks several cultivated crops. In other cases the pests can subsist upon native plants practically as well as upon the cultivated species. All these difficulties are absent in the case of the boll-weevil problem. The insect is absolutely restricted to the cotton plant for food and for opportunities for breeding. The problem, therefore, is much more simple than it would be if the weevil could subsist upon any other plant in the absence of cotton. This peculiarity of the weevil (i. e., no food plant but cotton) was the basis of the recommendation made in 1894 that the pest be exterminated absolutely in the United States by the abandonment of cotton culture in a very restricted region. At that time only a few counties in Texas were affected. The procedure would have involved but small expense. Even now the weevil could be exterminated in a single season by preventing both the planting of cotton and the growth of volunteer plants throughout the infested territory. This proposal has been made at various times, notably at the National Boll-Weevil Convention held in Shreveport, La., in 1906. Various difficulties, however, appear to render the plan entirely impracticable. In the first place, there would be strong opposition in large regions in Texas where the planters have learned to combat the weevil successfully. Moreover, the expense would be enormous. A large army of inspectors would be required. The work would not end with the prevention of the planting of cotton, but would necessarily extend to the destruction of volunteer plants which would be found along roads and railroads, about gins and oil mills, and on plantations throughout the infested region. The loss to mills, railroads, merchants, banks, and others dependent upon the cotton trade would complicate matters further. Unless a plan of reimbursement were followed, there would be strenuous opposition from these quarters, and any scheme of payment for damages would add very materially to the cost. From a theoretical standpoint, all the expenses involved would be justified. The saving in a few years would more than offset the cost. Nevertheless, the practical difficulties undoubtedly will always prevent the execution of the plan. All interests now favor the necessary adjustment of conditions to the boll weevil and the practice of the known measures of control rather than total eradication, which was once practicable, but now little more than visionary.

In Bulletin No. 114 it was shown that during the several years in which careful experiments have been performed the average rate of winter survival was 7.6 per cent. It is noteworthy that frequently the survival is much smaller. In the experiments to which reference has been made it ranged from 0.5 per cent to 20 per cent. The most important means of controlling the boll weevil that are available are designed to increase this tremendous mortality caused by natural conditions during the winter. The destruction of any certain number of weevils during the winter is much more important than the destruction of much larger numbers at any other season. The best means at the command of the farmer for increasing the winter mortality is through the uprooting and burning or burial of the stalks at an early date in the fall. Numerous experiments have shown the increased mortality due to depriving the weevils of their food at early dates in the autumn. In fact, the experiments showed a practically uniform increase in the number of weevils surviving as the dates of the destruction of the plants became later. For instance, in all of the experiments performed in Texas it was found that September destruction resulted in a survival of only 0.2 per cent; destruction two weeks later showed a survival of 2.3 per cent; destruction during the last half of October, 5.6 per cent; and during the first half of November, 15.4 per cent. The results of the Louisiana experiments were similar. Destruction in September showed a survival of 0.3 per cent; destruction in the first half of October, 2 per cent; in the last half of October, 8 per cent.

In addition to the experiments in which the weevils have been placed in cages at different times in the fall the Bureau of Entomology has conducted considerable field work to show the benefits of fall destruction. The most striking experiment was performed in Calhoun County, Tex., in 1906. In this experiment an isolated area of over 400 acres of cotton was utilized. There was no other cotton within a distance of 15 miles. By contracts entered into by the department, the farmers uprooted and burned all of the stalks during the first 10 days in October, 1906, and provision was made to prevent the growing of sprout cotton. As a check against this area, cotton lands about 30 miles away were used. Here the stalks were not destroyed in the fall, and the interpretation of the results of the experiment was based upon a comparison of the number of weevils present during the following season in the two localities. In May, 1907, following the destruction of the plants, careful search revealed only one weevil in the experimental area. In the check, however, the weevils were so numerous at this time that practically all of the squares had been destroyed. Examinations made later showed similar advantage in regard to freedom from the boll weevil of the area where the stalks had been destroyed the preceding October. The last examination was made on August 20, 1907. At this time there were 10 sound bolls per plant on the experimental area and only 3 per plant in the check area. The difference in yield between the two areas was about 600 pounds of seed cotton per acre. The work, therefore, resulted in an advantage amounting to about $18 per acre.

Newell and Dougherty[1] have described a very satisfactory device for cutting the cotton stalks in the fall. It consists of a triangular, V-shaped, wooden framework designed to pass between the rows and cut two at the same time. In the process of cutting the machine windrows the stalks from two rows in the middle near where they were standing. The runners are provided with knives made of sharpened metal. Old saws have been found well adapted to the purpose. It is important to provide a metal runner at the rear end of the machine to prevent sliding. This runner is designed to run an inch or more beneath the surface of the ground. The device can be made by any blacksmith at a cost of about $4. It will cut and windrow from 10 to 15 acres of stalks in a day.

---

[1] Circular 30, Louisiana Crop Pest Commission.

There is a disadvantage in cutting the stalks at or near the surface of the ground; this is that if warm weather follows, many of the roots give rise to sprouts that will furnish food for the weevils. On this account the process is less effective than uprooting the plants. Wherever the stalk cutter is used it should be followed by plows to remove the roots from the ground.

There is another important means by which the winter mortality of the weevil may be increased. This is by removing the hibernating quarters or destroying them after the weevil has gone into hibernation. Many of the insects are to be found in the winter in trash and débris in and about cotton fields. The more shelter provided in the form of weeds growing about the fields, the more favorable the conditions will be for the insect. By the burning of such hibernating shelter as is found in the cotton fields and in their immediate vicinity a farmer can cut off a very large proportion of the weevils that would otherwise emerge to damage the crop.

The prolonged period of emergence from hibernation gives the planter another important advantage over the weevil. The period of emergence from hibernation extends, in normal seasons, to practically the 1st of July. In fact, except in one of the experiments performed, the last weevils did not appear until after the 20th of June. In Texas it was found that 75 per cent of the emerging weevils appeared after April 8, and in Louisiana 64 per cent. In Texas, after May 1, in all the experiments, from 4 to 18 per cent of the surviving weevils appeared. In Louisiana, after May 1 from 30 to 40 per cent emerged.

It is obvious that the fact that many weevils do not appear until long after cotton can be planted and brought to a fruiting stage is a very great advantage to the planter. A portion of a crop, at least, can be set before the weevils have become active. Usually it is possible to plant a crop sufficiently early to have it set some fruit before much more than 50 per cent of the surviving weevils have emerged.

Attention was directed to the fact that the development of the weevil is much slower in the early portion of the season than later. For instance, at Vicksburg, Miss., the average period of development in April is 30 days, and in May 19 days. In June the period is shortened to 15 days. Consequently, the planter has an opportunity to force the development of fruit on the plants when the weevils are being held in check by the temperatures of the spring months. The ability of the cotton plant to grow during April and May is much greater than that of the weevils. This gives a margin of which the planter can take advantage.

It has been proposed at various times that late planting would be of advantage in the fight against the weevil, but exhaustive tests made by the Bureau of Entomology and the Louisiana Crop-Pest Commission have demonstrated the fallacy of this proposal.

In the section dealing with natural control it was shown that climatic checks are the most important that the boll weevil experiences. The principal manner in which climatic factors affect the weevil is through the drying of the fruit. Naturally, the more heat and light there is to reach the fallen squares the greater will be the effectiveness of the most important natural means of control. This is the basis for the recommendation that the plants should be given considerable space not only between the rows, but in the drill. Of course, it would be possible to place the plants entirely too far apart, and thus reduce the yield. There is a happy medium, however, at which planters must arrive from experience on their individual places. At the same time varieties should be cultivated which have a minimum tendency toward the formation of leafage.

The work of the insect enemies of the boll weevil is increasing from year to year. This work should be encouraged so far as possible. It happens that several of the recommendations made for other reasons will result in facilitating the work of the enemies of the weevil. This is the case with early planting, wide spacing, and the use of varieties with sparse rather than dense leafage. Even the fall destruction of the stalks is not a disadvantage, because it forces the parasites at the end of the active season to native hosts that carry them through the winter. Wherever possible varieties should be planted which retain a large proportion of the infested squares, because the hanging squares are more favorable for parasite attack than those which fall.

Whenever the squares are picked by hand they should, if practicable, be placed in screened cages, rather than burned or buried. In this way the weevils will be destroyed while the parasites may escape. The screen used on such cages should have meshes at the rate of about 14 to the inch.

Numerous experiments have shown that a large proportion of the weevils buried under 2 inches of moist soil can not reach the surface. Unfortunately, it is not possible to plow the infested squares under 2 inches of soil during the growing season. The operation would result in injury to the root system and cause great shedding.

Nevertheless, it is possible for the planter to follow this practice after maximum infestation has been reached and after the plants have been uprooted. Therefore, every means should be taken at the time of maximum infestation to plow under the infested squares as deeply as possible. This method is of little use in dry regions, but, fortunately, is of great importance in humid regions where other means of control are comparatively lacking in efficiency. Its importance is increased by the occurrence of large areas of so-called stiff soils in the humid area.

In 1909 the Louisiana Crop-Pest Commission published a circular dealing with the results of experiments with powdered arsenate of lead as a practical remedy for the boll weevil. This circular dealt with carefully planned field experiments which showed that the use of this arsenical was attended with great profit during that season. The Bureau of Entomology has investigated this subject for two subsequent seasons. The results have been to a certain extent contradictory, although there is an indication that a definite field of usefulness for the powdered arsenate of lead will be found. The results of this work will be published in due time. The striking results obtained by the Louisiana Crop-Pest Commission in 1909 seem to have been due to peculiar conditions, including a great abundance of insects, which prevailed during that season. The work of the Bureau of Entomology also shows that the greatest benefits will occur when the weevils are most abundant.

SUMMARY OF CONTROL MEASURES.

(1) *The destruction of the weevils in the fall by uprooting and burning or burying the plants.*—This is by far the most important step in control. It is so important that unless it is followed all other means will avail little to the planter.

The burning of the cotton plants is not, of course, a good agricultural practice. It should not be followed except in emergencies. In all other cases the plants should be uprooted as soon as the cotton can be picked, cut by means of stalk choppers, and plowed under immediately. The ground should afterwards be harrowed or dragged to make it still more difficult for the insects to emerge.

In many cases it will be found inadvisable to wait for the uprooting of the plants until all of the cotton is picked. When only a small portion remains for the pickers it is entirely feasible to uproot the plants by means of a turning plow and leave them in the field so that the cotton can be picked. This will hasten the opening of the green bolls and frequently result in a considerable saving to the planter.

(2) *The destruction of the weevils during the winter.*—This is accomplished by the destruction of the places in which the insects hiber-

nate. Many such places are found in the cotton fields or in their immediate vicinity. A certain number of the weevils will, of course, make their way into the heavy woods and other situations beyond the reach of the planter, but many remain where they can be reached.

(3) *Obtaining an early crop.*—The importance of obtaining an early crop has been shown to depend upon the small number of weevils which hibernate successfully, their late emergence from hibernating quarters, and their comparatively slow development during the early part of the season. The obtaining of an early crop is brought about by early preparation of the soil, by early planting, the use of early maturing varieties,[1] a system of upbuilding and fertilization which will stimulate the growth of the plants, and by continuous shallow cultivation during the season.

By early planting we do not mean that the planter should run great risk of loss of stand by frost. Planting at too early a date is as bad as late planting. By early planting we mean the earliest planting that the farmer's experience shows is reasonably safe.

(4) *Increasing the effects of climatic control.*—As has been shown, practically 50 per cent of all the weevil stages throughout the infested territory are destroyed by climatic influences. This means that the power of reproduction of the weevils is reduced by one-half. A planter can increase the advantage in his favor by providing a suitable distance between the plants and between the rows. It is also important to use varieties, where possible, which have a comparatively small leaf area.

(5) *Encouraging the insect enemies of the weevil.*—This is accomplished in part by procedures already recommended and, further, by the use of varieties which have a well-developed tendency to retain the fruit, and which also have a comparatively open structure and small leafage.

(6) *Hand picking of weevils and squares.*—This is a practice of varying importance. Under some conditions it may be highly advisable, under others entirely impracticable; everything depending upon the cheapness with which the work can be done. * * * It is therefore a matter that must be taken into consideration by each individual planter. This subject is now under investigation by this bureau, and the experiments under way will show under what conditions the practice of picking the squares or weevils can be recommended.

Wherever square picking is practiced the best results are likely to follow where the picked-up squares are placed in cages so that the parasites may escape and continue their work. As a matter of fact, under most conditions it is likely that the encouragement that can be given the parasites by this means is of much more importance than any direct checking of the weevil by the process of hand picking. Wherever squares are burned these enemies of the weevil are destroyed, thus stopping their beneficial work. It is of the utmost importance, however, that the cages in which the squares are held be free from cracks or openings such as result from the shrinkage or warping of the wood in barrels and boxes that are left exposed to the weather, through which the weevils could escape, and that the screen used on them have meshes at the rate of about 14 to the inch.

---

[1] Some of the best varieties for the humid region (Louisiana, Mississippi, and Alabama) are Cleveland's Big Boll, Cook's Improved, Toole's, and King. In Texas, Mebanes Triumph, Rowden, Lone Star, and other varieties will be found best adapted to boll-weevil conditions. For further information the planter should communicate with the Bureau of Plant Industry or the State Experiment Station.

(7) *Control at gins.*—The use of modern cleaner feeders will eliminate practically all of the weevils from cottonseed. Such devices should be used at least in the case of all seed that is intended for shipment into any infested localities, and especially along the outer border of the infested territory, where wagons may carry infested cottonseed some distance into territory that has not been reached by the weevil. It is important in connection with the cleaner feeders to provide some means for the destruction of the insects that are captured. In some cases where the cleaner feeders are in operation the discharge is allowed to accumulate in an open barrel or box. From such receptacles weevils readily make their way into the seed cotton in storage. It is a simple matter to provide compression rollers through which the discharge from the cleaner feeder is passed. If for any reason the use of compression rollers is impracticable the trash should be fumigated at frequent intervals by means of carbon bisulphid or collected in a closed chamber and burned before the weevils have an opportunity to escape.

(8) *Fumigation of seed.*—This is a means of repression that will be of avail only in the case of shipments of seed into uninfested territory. It has been found that carbon bisulphid is the most satisfactory agent to use. Great care should be taken to insure thoroughness of application.

In addition to the specific means of control enumerated we may mention the prevention of the invasion of new territory by means of quarantines directed against farm commodities that are likely to carry the weevil. It is not necessary to have a quarantine applied to an extended list of articles. Only a few forms of cotton and of cotton by-products need to be considered. The most important is seed cotton. Next in importance are cottonseed and cottonseed hulls. There is no danger in cottonseed meal and scarcely any appreciable danger in baled cotton.

Cottonseed can easily be rendered entirely safe by fumigation with carbon bisulphid.

The use of a crossbar attached to the cultivator to jar the infested squares from the plants has frequently been recommended. Under some conditions this practice should be followed, but under others it is worse than futile. It has been found that in the humid region, including Arkansas, Louisiana, and the eastern portion of Texas, the mortality in hanging squares is greater than in fallen squares. For this reason it is better for the squares to remain on the plants. There is another reason why they should be allowed to remain on the plants, which applies especially to the moist region in which the boll weevil is now doing great damage. This is that the hanging squares are much preferred by the boll-weevil parasites. The records have invariably shown a higher rate of parasitism in hanging squares than in fallen squares. In this way the hanging squares furnish a means for the breeding of parasites and their establishment in the field.

It will be noted that the means of repression of the boll weevil may be divided into two classes, namely, direct and indirect.

The direct means of control are the destruction of the weevils in the fall by destroying the plants and burning or burying the immature stages, hand picking of weevils and squares under some conditions, poisoning with powdered arsenate of lead, the burial of the infested forms at the time of maximum infestation, and the burning of the hibernating weevils in their winter quarters.[1]

The indirect means of control are early planting, the use of early varieties and of fertilizers that will accelerate growth, the improvement of the soil by the incorporation of humus, the selection of fields where the soil is suitable to rapid development, frequent shallow cultivation, the encouragement of the parasites of the weevil by placing the infested squares that may be picked by hand in cages instead of burning them, and the use of machinery which facilitates the various operations in preparing the land and cultivating the crop. These have the effect of increasing the acreage that a hand may cultivate. In view of the fact that the boll weevil forces a reduction in the acreage per hand, this is a consideration of some moment.

---

[1] Poisoning the adults with powdered arsenate of lead, judging by experiments now under way, will also serve as a direct check. Definite advice can not be given until the field experiments are completed.

DEC 2 1925

BOSTON PUBLIC LIBRARY

3 9999 04657 707 6